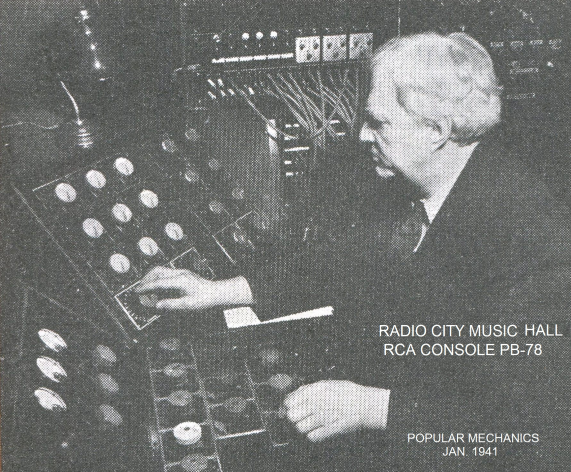

RADIO CITY MUSIC HALL
RCA CONSOLE PB-78

POPULAR MECHANICS
JAN. 1941

JOURNAL
OF THE SOCIETY OF
MOTION PICTURE ENGINEERS

Volume XXI **SEPTEMBER, 1933** **Number 3**

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RADIO CITY SOUND EQUIPMENT*

BARTON KREUZER**

Summary.—*The paper describes the equipment used in the Radio City Music Hall, explains the mode of operating it, and the use of the component systems; it refers to the engineering design of the various portions of the system, their performance, and some of the installation problems involved.*

The term Radio City has been somewhat loosely applied in the past. Radio City is that part of Rockefeller Center occupied by the Radio Corporation of America and its associated companies. Rockefeller Center lies between Forty-eighth and Fifty-first Streets and Fifth and Sixth Avenues in New York City. The theatrical part of this enterprise consists of two theaters, the "RKO Roxy Theater," seating 3700 persons, and the "Radio City Music Hall," seating 6200. The remarks in this paper will be restricted to the latter theater, since, from an equipment and engineering standpoint, the smaller theater is a proportionately smaller copy.

A considerable number of systems were involved in equipping the Radio City Music Hall. They may be summarized as follows:

I. Sound on film reproducing equipment.
    A. Double channel equipment main projection booth.
    B. Rear projection equipment.
    C. Portable film phonograph.
    D. Two complete preview rooms.
II. Public address and sound reinforcing equipment.
III. Rehearsal system.
IV. Sound effect system.
V. Stage manager's call system.
VI. Radio frequency distribution system.
VII. Custom built radio, phonograph, and monitoring system.

The sound-on-film reproducing equipment is of the latest "high fidelity" type, employing the newly developed sound-heads shown in Fig. 1. The main projection booth is equipped with four projectors

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* Presented at the Spring, 1933, Meeting at New York, N. Y.

** RCA Victor Co., Inc., Camden, N. J.

and a double-channel 80-watt amplifying system, which is completely a-c. operated. This assures a complete "standby" equipment for emergency use, which can be placed in immediate operation by turning a single knob. A further guarantee against interruption is the fact that the 80-watt output is obtained from two 40-watt amplifiers coupled together so that all stage speakers will be supplied with energy even if one of the two power amplifiers should become inoperative.

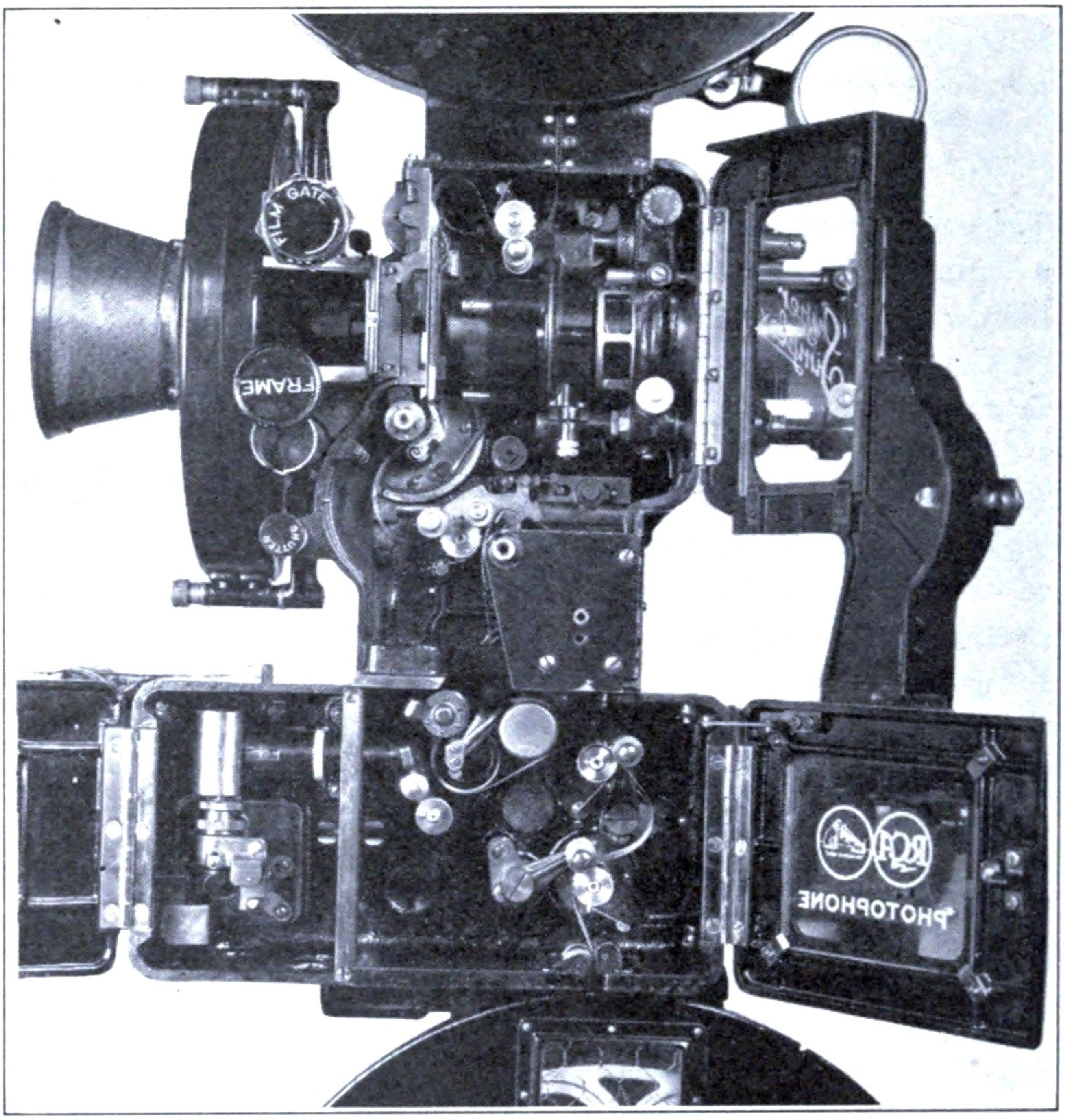


FIG. 1. New sound-head.

Amplifier volume and fading from one projector to another are controlled remotely by push buttons located adjacent to the projectors. Key-operated remote volume control stations have also been placed throughout the theater.

The stage loud speakers consist of three 10-foot directional baffles and three 5-foot directional baffles. The larger speakers are placed in a horizontal line so as to cover almost the entire house with the exception of the front part of the orchestra, which is covered by the three smaller speakers hung directly beneath the others. These

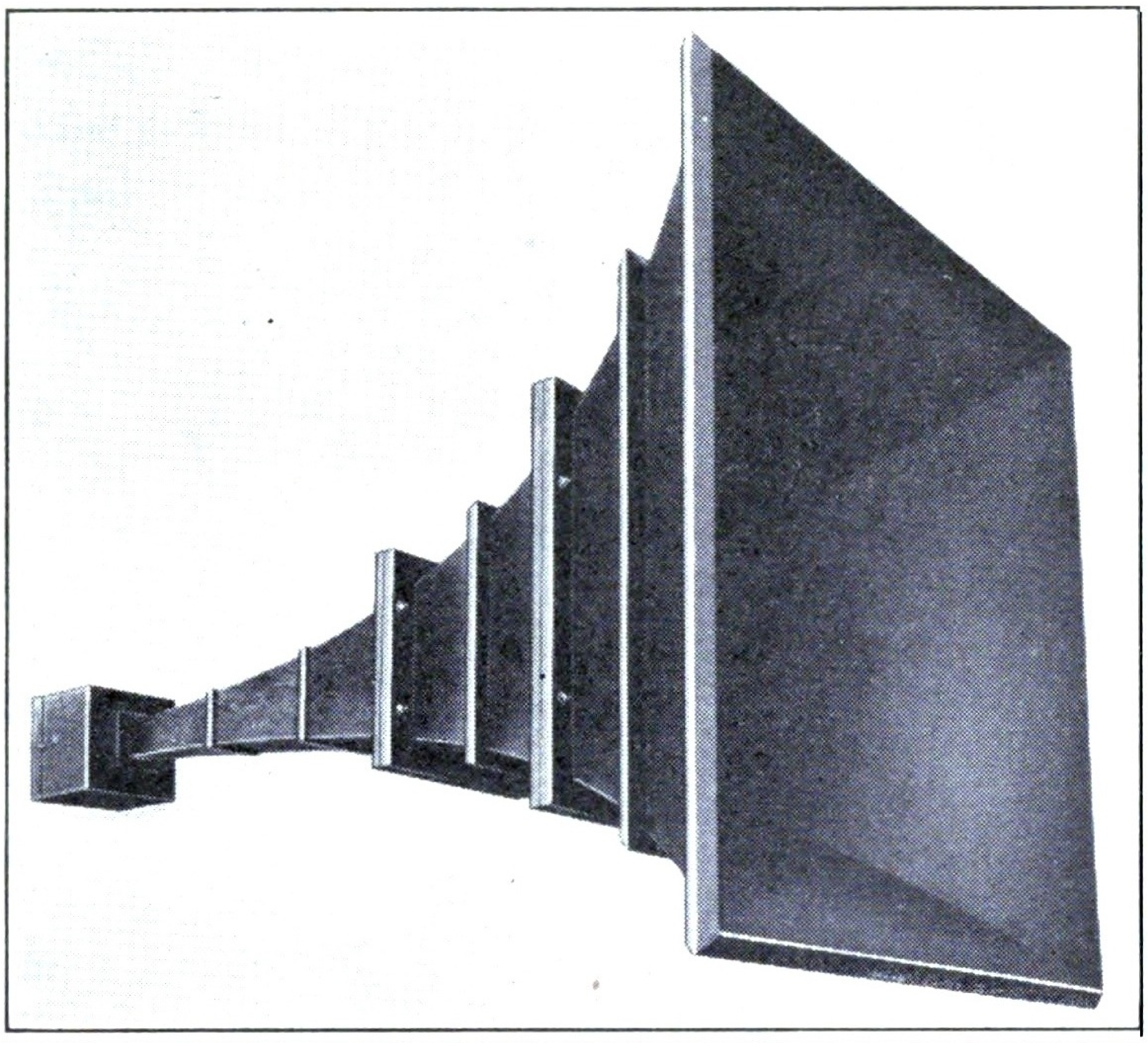


FIG. 2. Stage loud speaker.

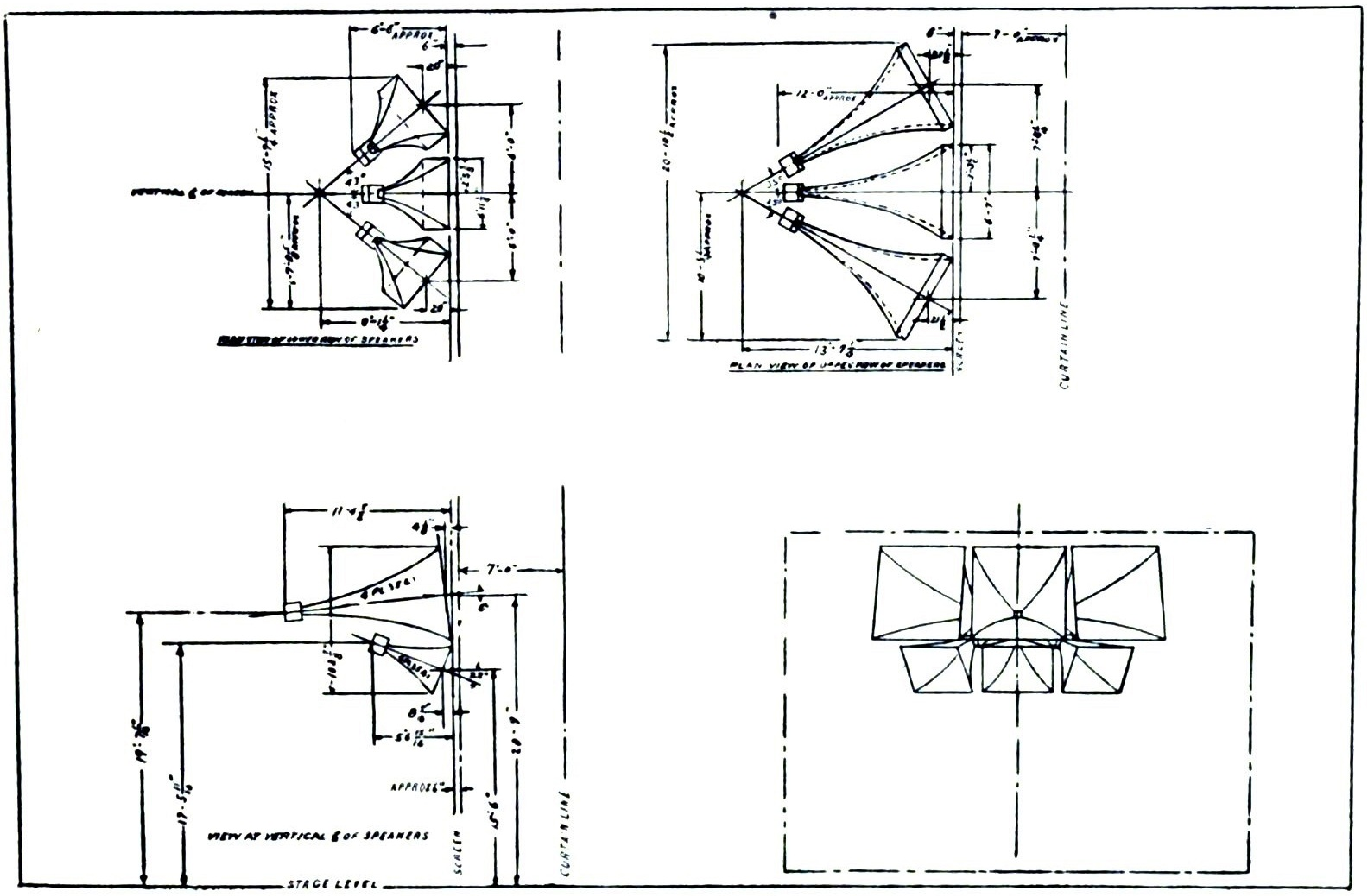

6'-6" APPROX.
6"
15'-9¼" APPROX.
43°
6'-0"
8'-1½"
PLAN VIEW OF LOWER ROW OF SPEAKERS
6"
7'-0" APPROX.
12'-0" APPROX.
20'-10½" APPROX.
35°
10'-5¼" APPROX.
6'-7"
13'-7⅜"
PLAN VIEW OF UPPER ROW OF SPEAKERS
SCREEN
CURTAIN LINE
11'-4⅞"
7'-0"
APPROX. 6"
VIEW AT VERTICAL ℄ OF SPEAKERS
SCREEN
CURTAIN LINE
STAGE LEVEL

FIG. 3. Layout of stage loud speakers.

speakers are of the large throated, electrodynamic cone type. They have been previously described in the JOURNAL.[1] Fig. 2 is a photograph of one of the large directional baffles and Fig. 3 shows the speaker positions.

These speakers are mounted in metal "cages" and are provided with an electric motor system that folds the three large baffles, removes all the speakers to the "wings" (four to the Opposite Prompt side and two to the Prompt side) and "flies" all speakers in fifty-five seconds. This achievement is due to Peter Clark, Inc.

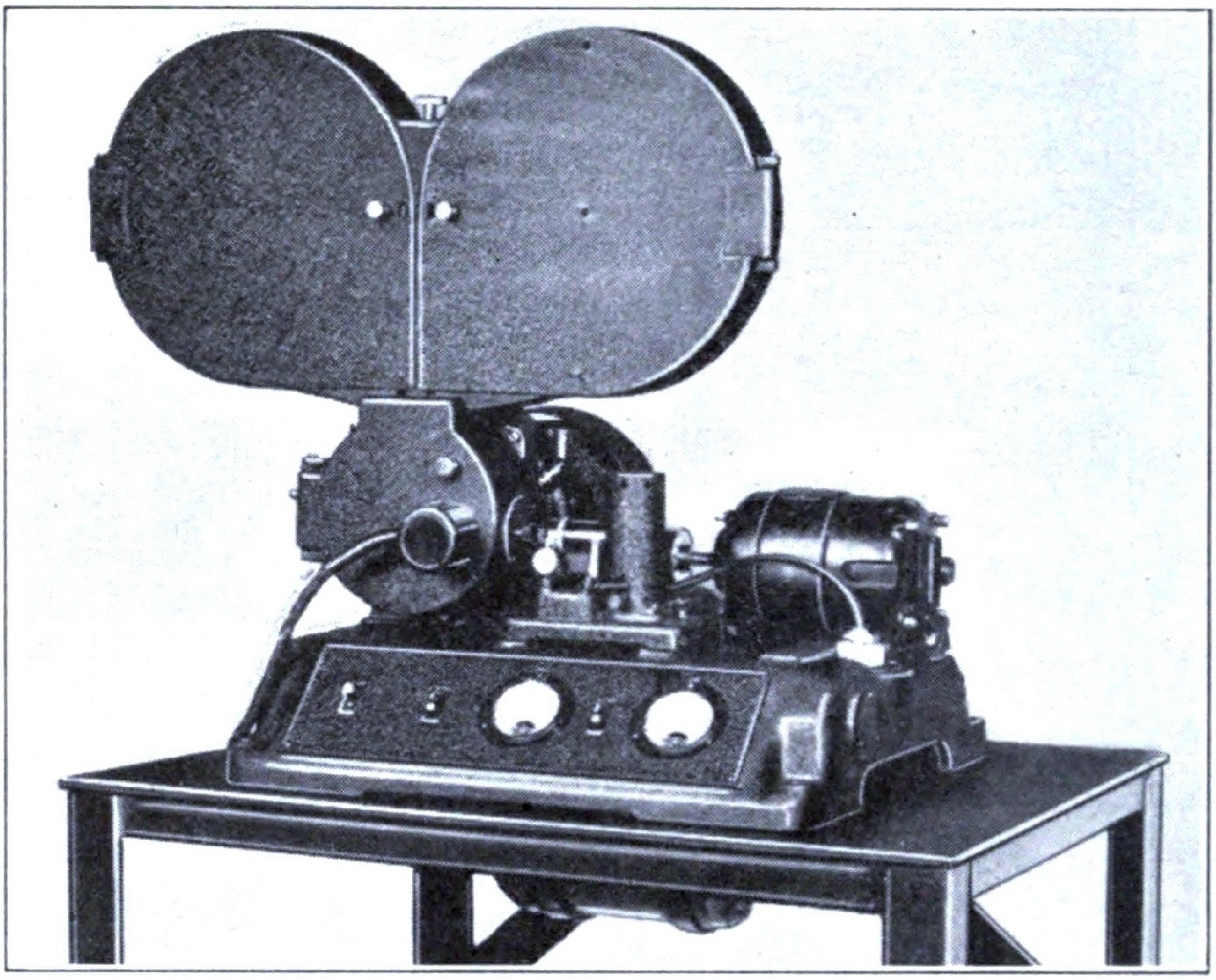


FIG. 4. Film phonograph.

The rear projection equipment, which may be used to create "panoramic" backgrounds or to project regular pictures, is similar to that employed in Translux theaters. For the sound equipment newly developed sound-heads are used and an a-c. operated booster amplifier is provided for transmitting the signal to the main projection room where it may be fed into one of the several systems mentioned.

The film phonograph is a portable table-mounted machine employing the magnetic drive which has been so successful on RCA Photophone film recorders. This assures the reproduction of sound of the highest quality from film, with absolute freedom from speed variations of any kind. This film phonograph is pictured in Fig. 4. Two positions are provided for it, *viz.*, in the rear projection room and the main projection room. Connections are quickly made to wall receptacles.

The preview rooms, together with a broadcasting studio, rehearsal halls, *etc.*, are located two stories above the projection room level. These rooms are equipped with "high fidelity" film reproducing equipment of the latest design, completely a-c. operated, with push-button remote control. One push-button location is in the auditorium, so that the listeners may regulate the volume to their own satisfaction. This is particularly valuable in viewing "rushes" of various types. In engineering this project, these two preview rooms were treated as separate theaters and were so equipped.

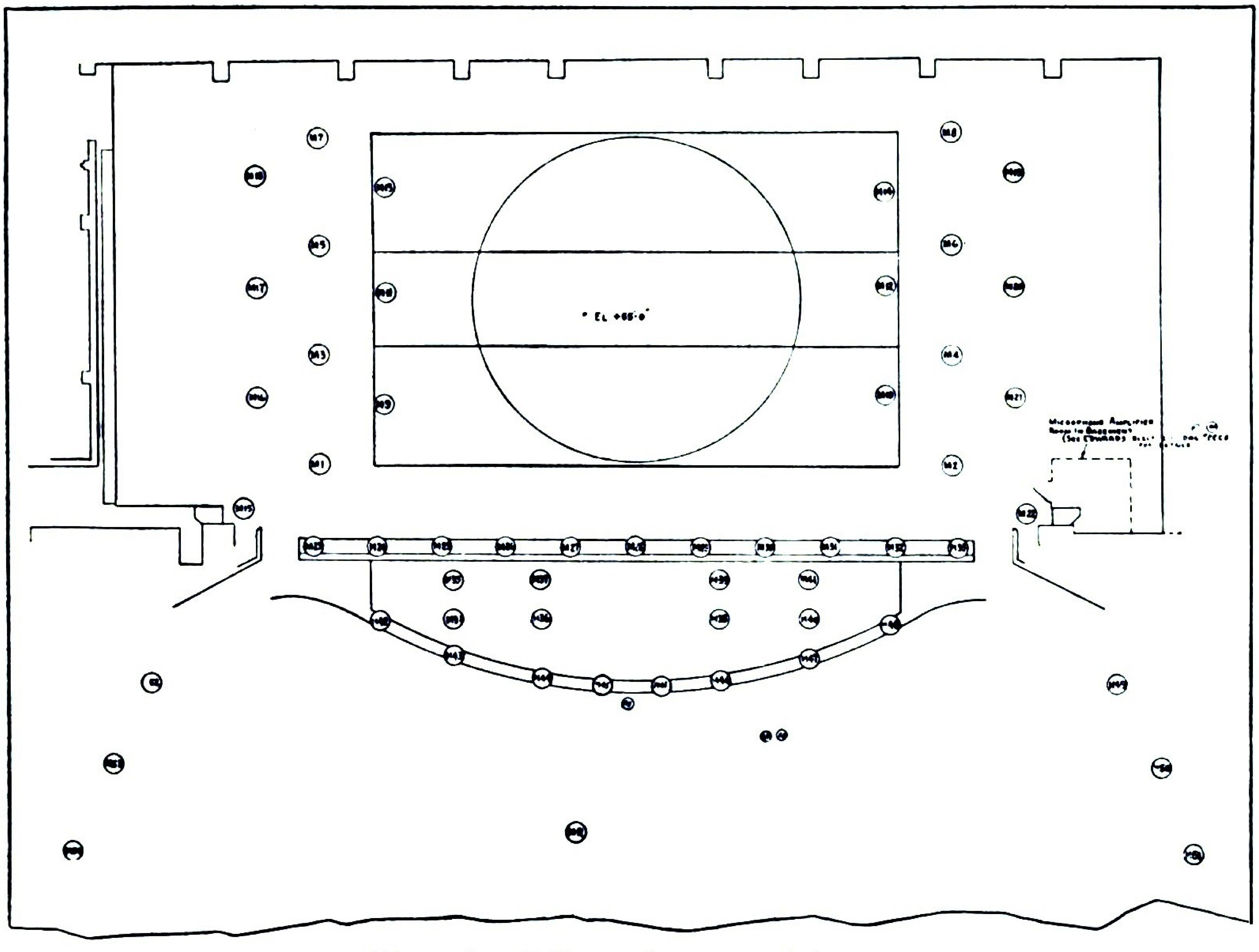


FIG. 5. Microphone positions.
(RADIO CITY MUSIC HALL)

The public address and sound reinforcing system utilizes ribbon microphones,[2] a-c. operated 80-watt amplifiers, and a mixer console and remote control panels, both of which are unusually flexible. The system is used, of course, to reinforce sound emanating from the stage or as a public address system that can be used, for instance, by an unseen person making announcements to the audience, and for other similar purposes. Six of the 3-foot directional baffles are used for loud speakers. These are concealed behind lighting grilles above and on either side of the proscenium arch.

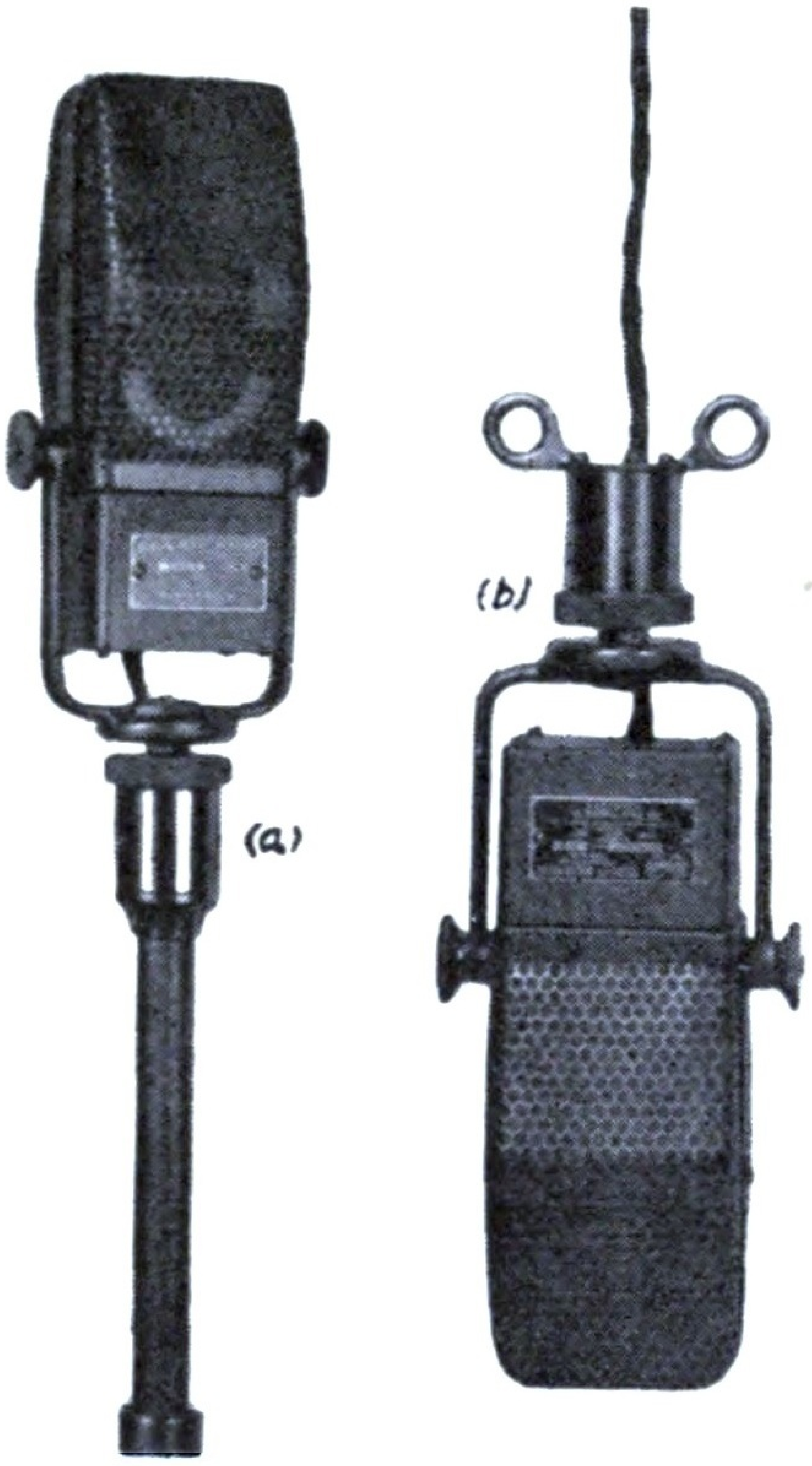


FIG. 6. Ribbon microphones (*a*) stand type; (*b*) hanging type.

There are 54 microphone positions on or above the stage, including those on the choral stairs. The most notable of these, perhaps, are eleven positions built into the disappearing footlights and eight positions in metal boxes whose tops are grilles made flush with the floor of the orchestra elevator. There are eight positions on the light bridges above the stage. Fig. 5 shows all the positions. Fig. 6 shows one of the ribbon microphones.

Fig. 7 is a skeleton diagram of the entire public address system. Many liberties have been taken in making this drawing for the sake of clarity and typical circuits rather than actual connections are shown. Audio circuits are shown as solid lines and power supply circuits as broken lines. Control circuits have been omitted, but some of the functions of the control racks have been marked adjacent to them. No interconnections to other systems are shown.

The output of the microphones is carried on intermediate im-

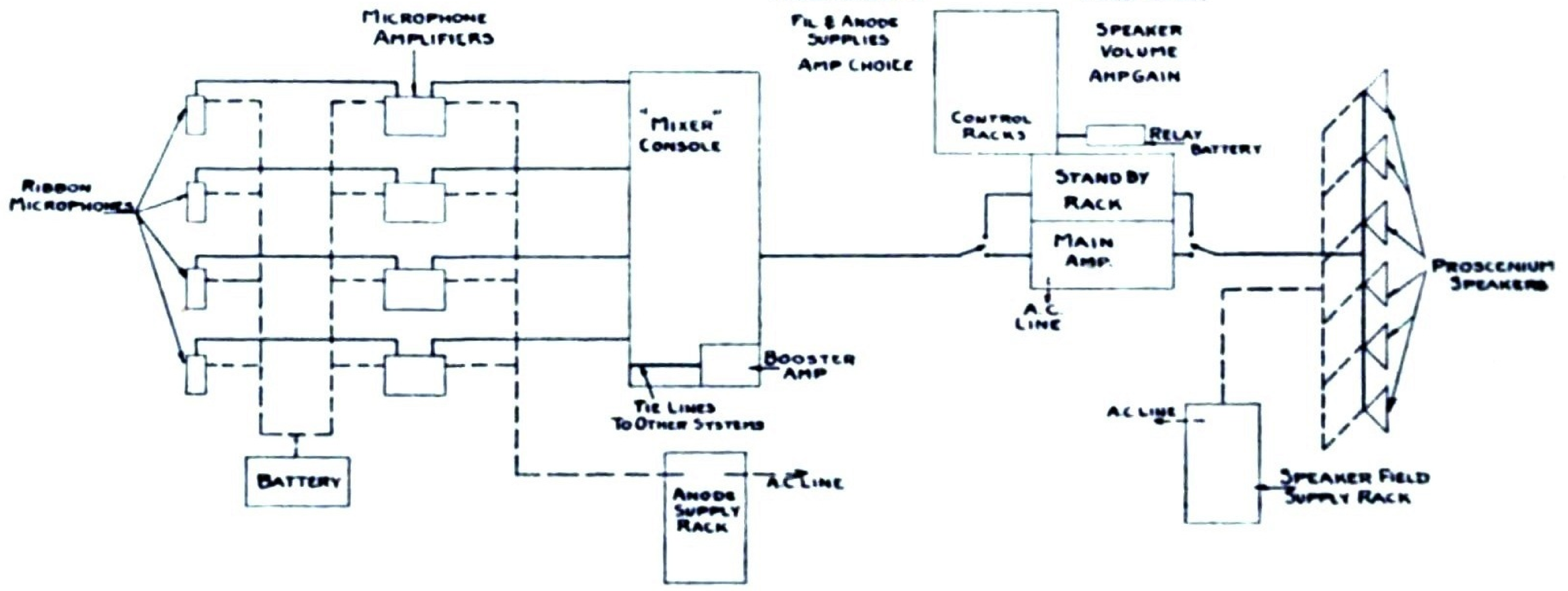

MICROPHONE AMPLIFIERS
MICROPHONE AMP.
FIL & ANODE SUPPLIES
AMP CHOICE
MICROPHONE FIELD SUPPLY
SPEAKER VOLUME
AMP GAIN
RIBBON MICROPHONES
"MIXER" CONSOLE
CONTROL RACKS
RELAY
BATTERY
STAND BY RACK
MAIN AMP.
A.C. LINE
PROSCENIUM SPEAKERS
BOOSTER AMP
TIE LINES TO OTHER SYSTEMS
BATTERY
AC LINE
ANODE SUPPLY RACK
AC LINE
SPEAKER FIELD SUPPLY RACK

FIG. 7. Schematic diagram of the public address system.

pedance lines to the basement amplifier room where racks of microphone amplifiers with non-microphonic vacuum tubes are located. This type of amplifier is shown in Fig. 8. Filament current for these amplifiers and field current for the ribbon microphones are supplied by a 1000-ampere-hour glass cell storage battery located on the projection room level. This is a double-channel battery installation, one set being charged while the other is in use. Other than a smaller double-channel glass cell battery installation used for relay operation, no other battery power is used in any of the systems.

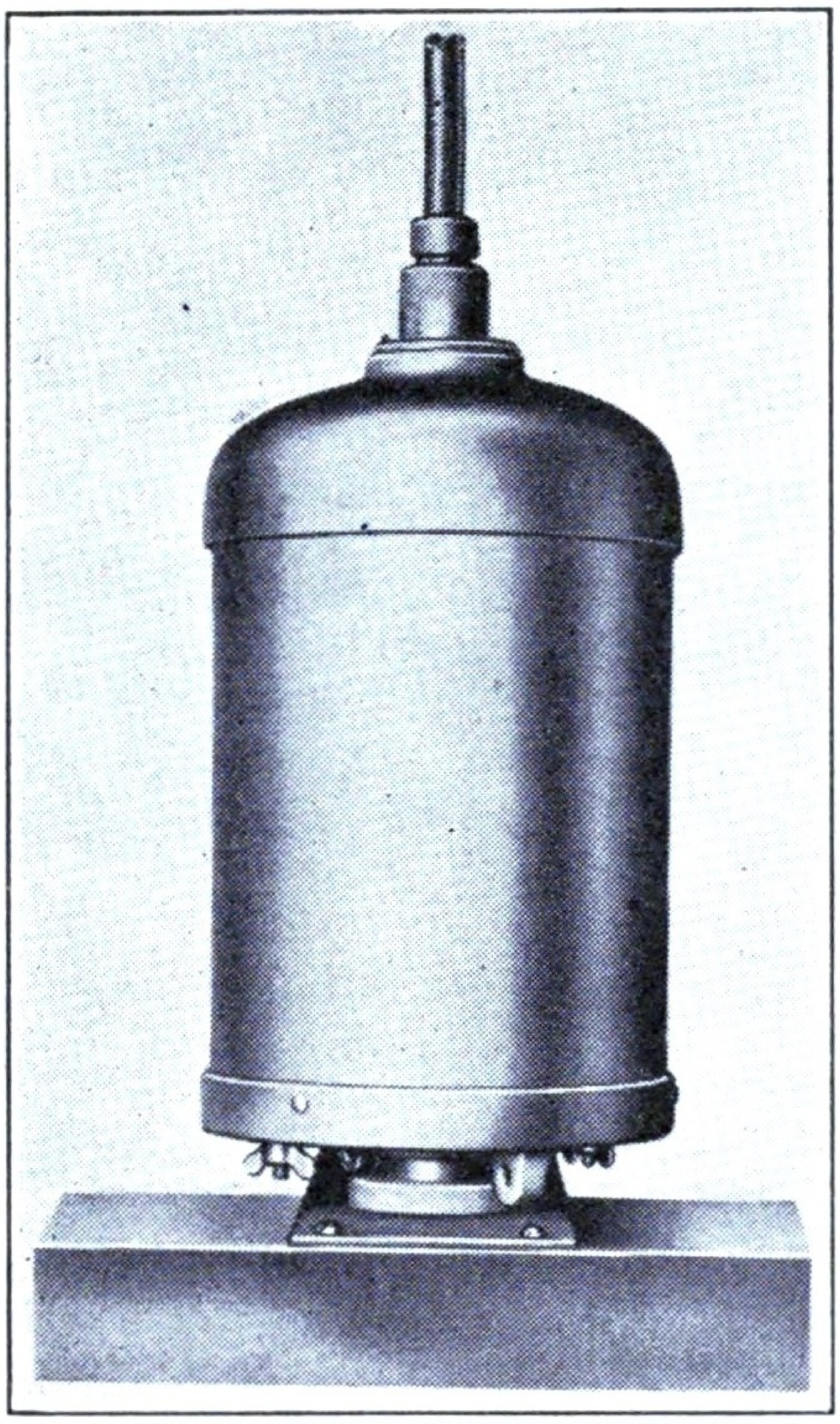


FIG. 8. Microphone amplifier.

The microphone amplifiers derive their plate supply from mercury vapor rectifier tubes in a power supply rack located on the projection room level. These rectifiers are also in a double-channel arrangement. The output of the microphone amplifiers is brought to the "mixer" console where the lines terminate in jacks. All mixer controls terminate in telephone plugs of the switchboard type with flexible drop-cords. In this manner, any microphone position may be connected to any mixer. There are four groups of these mixers, each group colored differently. The output of each group is brought to a correspondingly colored sub-master, which feeds into a single-stage booster amplifier located in the console itself. The amplifier employs a non-microphonic tube. At the output of the booster, the over-all master control is located. A volume indicator of the copper oxide rectifier type is built into the console and may be patched into any point in the circuit.

The console is shown in Fig. 9. It is constructed and placed so that the operator may have an unobstructed view of the stage and a portion of the auditorium proper. At the right may be seen the cords and jacks referred to above, and to the left may be seen a jack panel where tie lines to the other systems terminate.

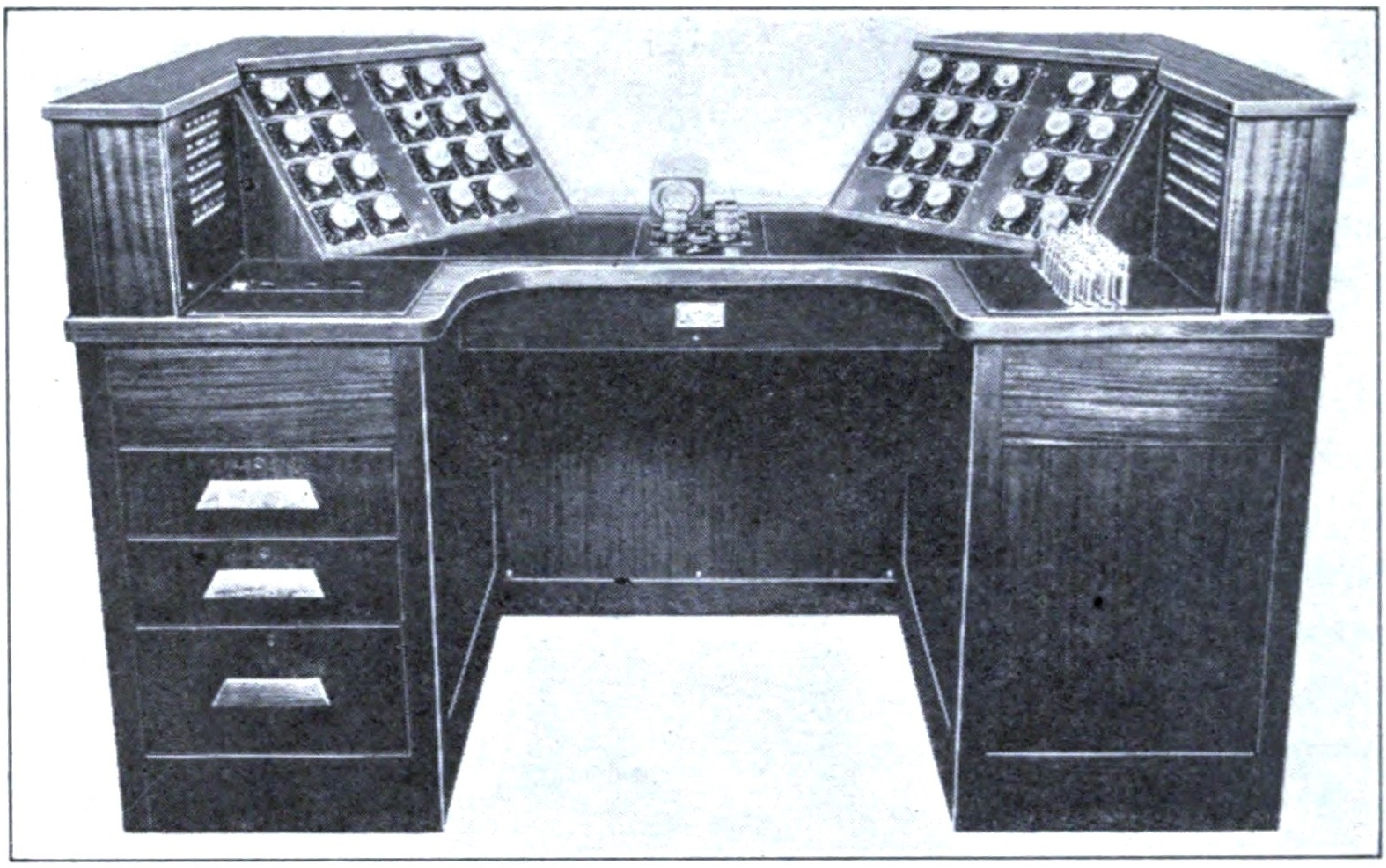


FIG. 9. Microphone mixer console.

The output of the console is fed to the main amplifier or the standby amplifier, both of which are 80-watt amplifiers similar to those employed in the projection system. The output of this amplifier passes through a control panel, where an individual volume level may be established for each loud speaker, and thence to the loud speakers themselves. This control panel is part of two control racks located adjacent to the mixer console, shown in Fig. 10. Other functions of these control racks are to furnish control of all power-supply circuits by means of relays, selection of amplifier channels both for the main amplifier and for seatphones, selection of projection or public address program for seatphones, *etc.* In addition to this, a monitor loud speaker is provided on these racks fed by a separate amplifier, which may be connected to any of the systems at the operator's discretion. This provides a rapid check on the operation of all systems.

The rehearsal system, electrically, is a duplicate of the public address system but employs three ribbon microphones, located in the private box, the console box, and the twelfth row of the orchestra. The last is built into a portable desk which is used only during rehearsals. In addition to these, one carbon microphone station is built into the stage switchboard for the use of the chief electrician. These microphone outputs pass through a mixer panel located on the control racks mentioned above and thence to another 80-watt amplifier. The output of this amplifier supplies thirty-two 3-ft. directional baffles located at strategic points off-stage, below stage, in spotlight booths, projection room, *etc.* In addition, magnetic speakers of the wall type are used in a few locations, such as in the orchestra pit elevator shaft, choral stairways, *etc.*, where low volume is satisfactory. The level of the speakers is controlled in groups at the control racks.

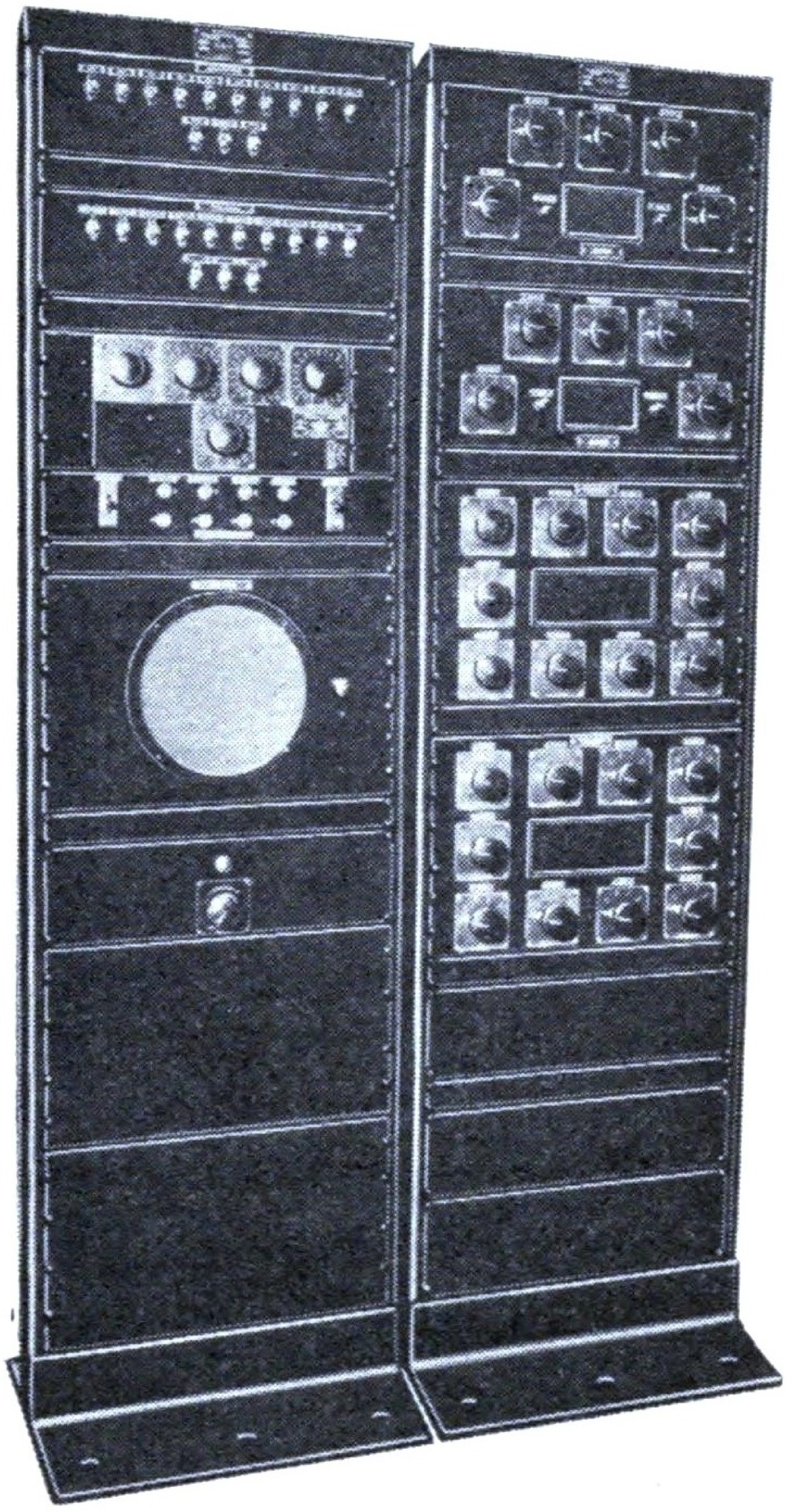


FIG. 10. Control racks.

Three-foot portable speakers are used also to cover the front portion of the stage when addressing the cast, and are removed and stored together with the twelfth row microphone whenever there is an audience present. This system, which is most useful during rehearsals for talking to actors and stage hands, is almost invaluable for cueing during stage presentations when operated at a low level.

The sound effect system employs an 80-watt amplifier of the type described previously, which in emergencies is used as standby for the public address amplifier. Ordinarily, it is used to amplify sound effects created either by microphone pick-up from backstage, disk or film reproduction. Disk reproduction comes from a battery of four turntables capable of revolving at either $33^1/_3$ or 78 rpm., and allowing the pick-up to be pre-set at any desired point of the record. The pick-up is suspended above the record while the latter revolves. At the desired moment, a button is pressed, the oil-damped pick-up is lowered gently to the record, and the desired "effect" is reproduced without any delay in attaining the required speed or in locating the correct groove. This arrangement allows very precise timing. The outputs of the turntables are controlled at a small mixer table placed near the large mixer console.

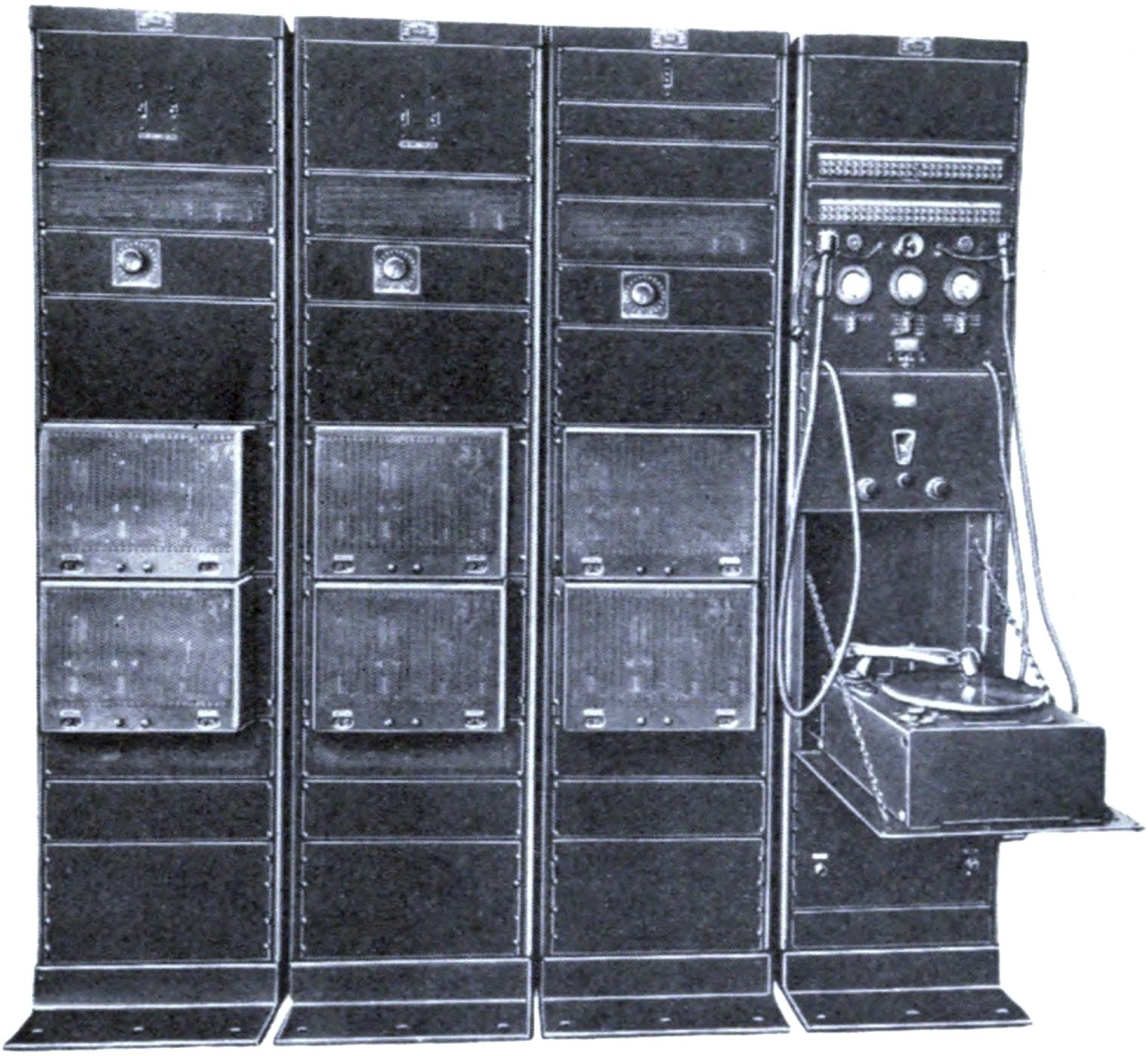
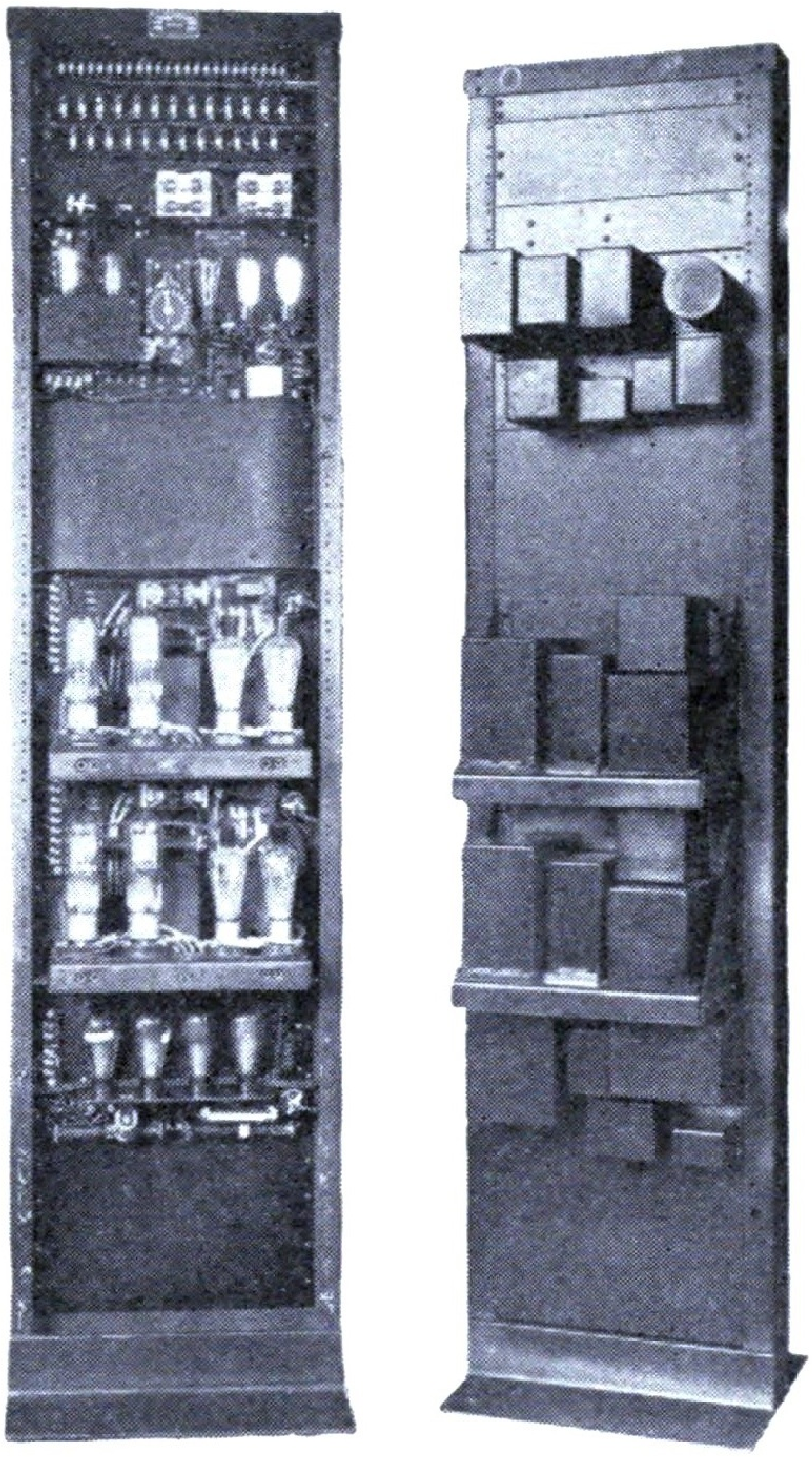


FIG. 11. Public address, effect, rehearsal, and miscellaneous amplifier racks.

The output of the "effect" amplifier supplies two gigantic directional baffles located in a separate room behind the cyclorama at the rear of the stage. Each of these baffles has a mouth opening of $19^1/_2$ by 12 feet, and is 20 feet long. The baffles terminate in four throats, each of which is supplied with sound energy by an electrodynamic cone unit. These loud speakers reproduce frequencies as low as 30 cycles per second.

Each of the four systems described so far is provided with remotely operated volume controls, which can be manipulated by means of push-buttons at the control racks adjacent to the mixer console.

Fig. 11 shows the rack assembly comprising the public address, effect, and rehearsal amplifier channels. In addition to these, a miscellaneous equipment rack is shown, which contains a sensitive radio receiver, a turntable, a tube tester, and patching panels. The radio and turntable may be patched into any channel for testing or for any special purpose. Fig. 12 is a front and rear view of one of the eighty-watt amplifier channels with the cover plates removed. Seatphone amplifiers may be seen at the bottom.

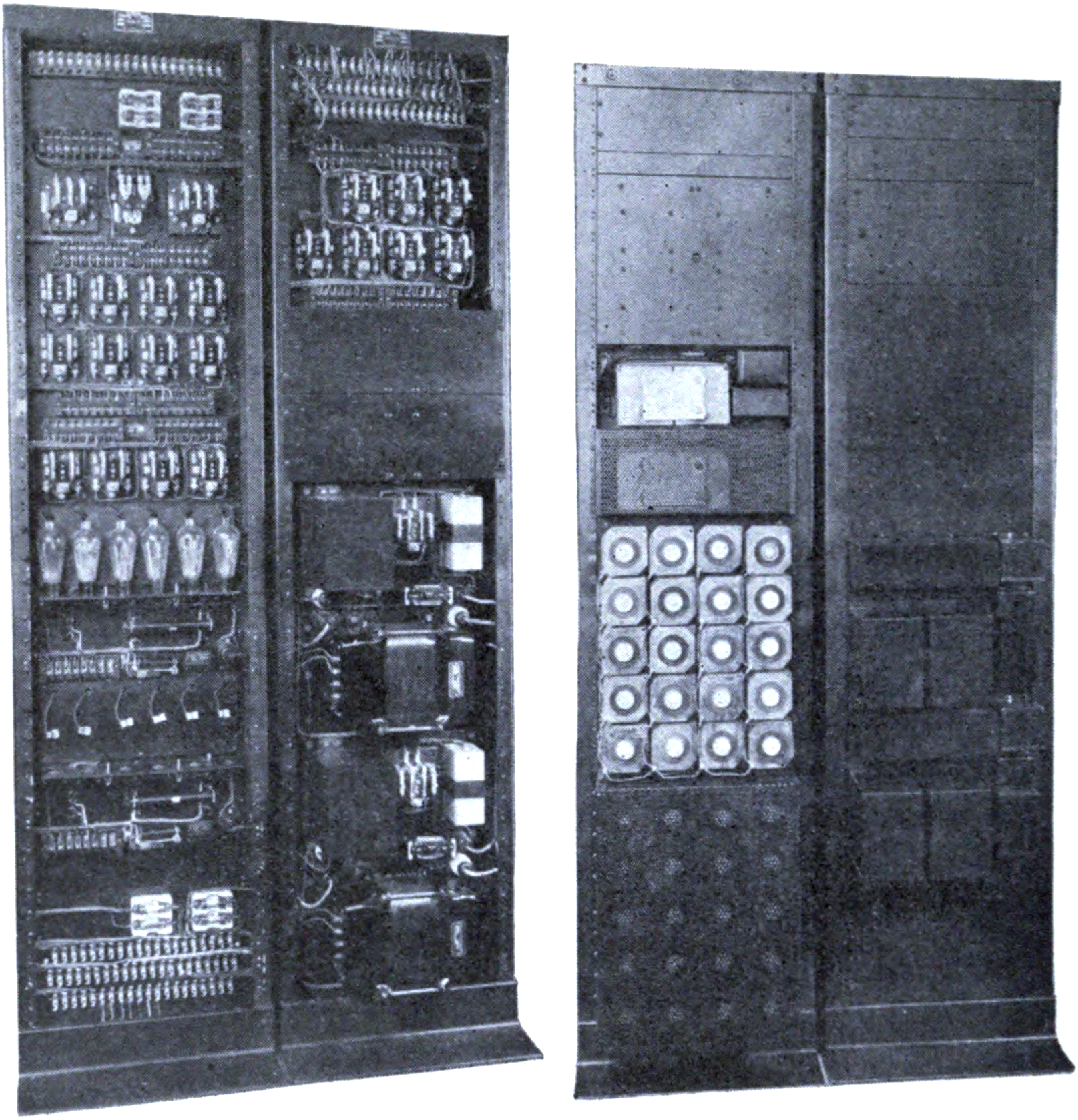


(*a*) (*b*)

FIG. 12. Eighty-watt amplifier and seatphone amplifier with cover plates removed (*a*) front; (*b*) rear.

Fig. 13(*a*) shows the two power-supply racks with the front covers removed, exposing the mercury vapor rectifiers and the various relays. Fig. 13(*b*) shows the rear of these racks, including the main and standby channels for supplying field current to the loud speakers. These consist of copper oxide rectifiers.

Fig. 14 shows the circuits employed in the voltage amplifiers, Fig. 15 those used in the power amplifier and Fig. 16 shows the



(*a*) (*b*)

FIG. 13. (*a*) Power-supply racks with cover plates removed, front view; (*b*) two guards removed, rear view.

over-all frequency response of the public address system from uniform acoustic input to the microphone to acoustic output in the auditorium from the loud speakers. The characteristics of sound reproduced from film are equally excellent. The variations that do exist have been definitely proved to be room characteristics, and no corrections have been made because the "weighting" of these factors is so often open to question and the actual variations from uniformity are not great.

The stage manager's call system consists of a carbon microphone station, built into the stage switchboard, which feeds a 40-watt

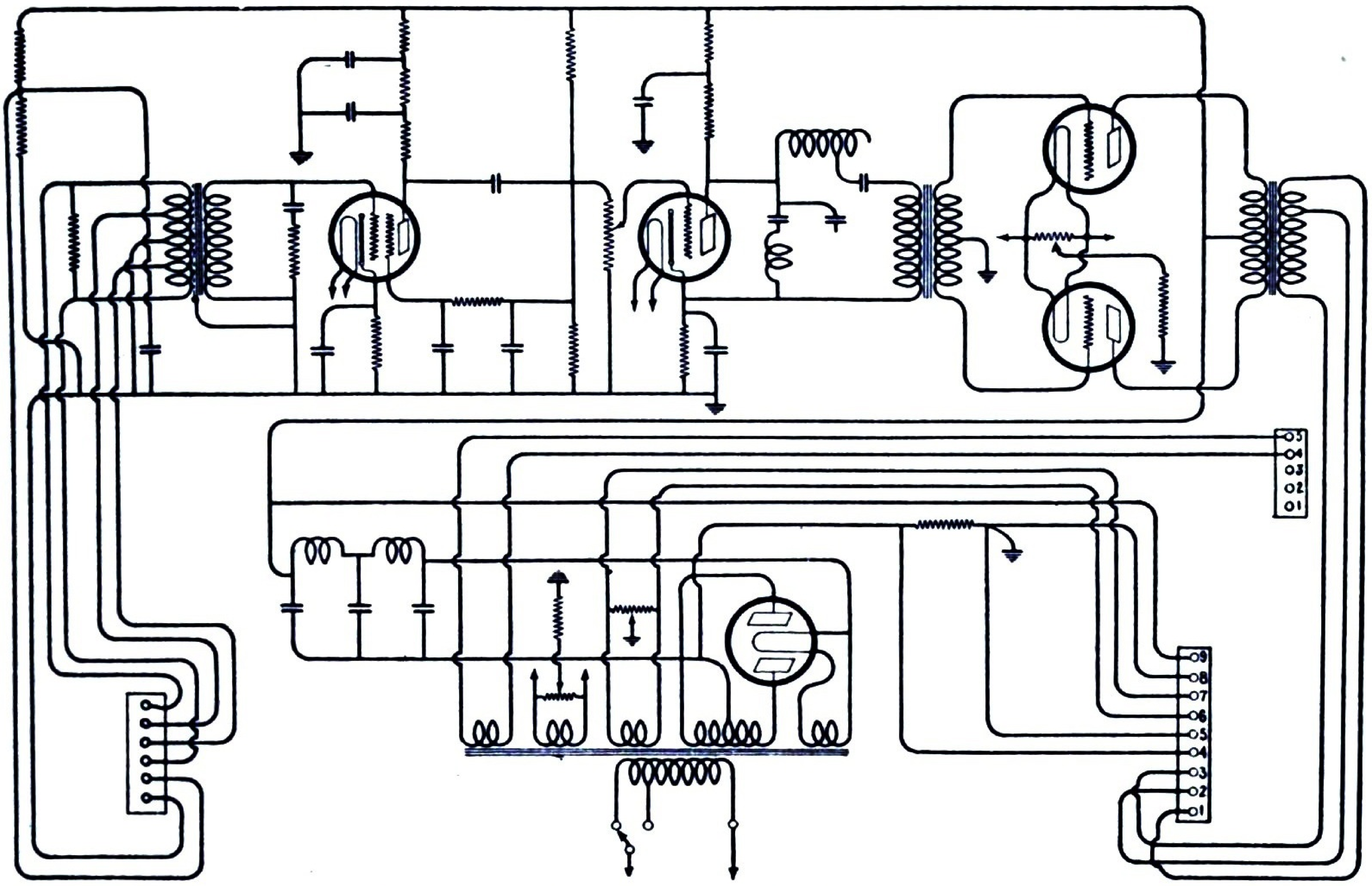


FIG. 14. Voltage amplifier circuit.

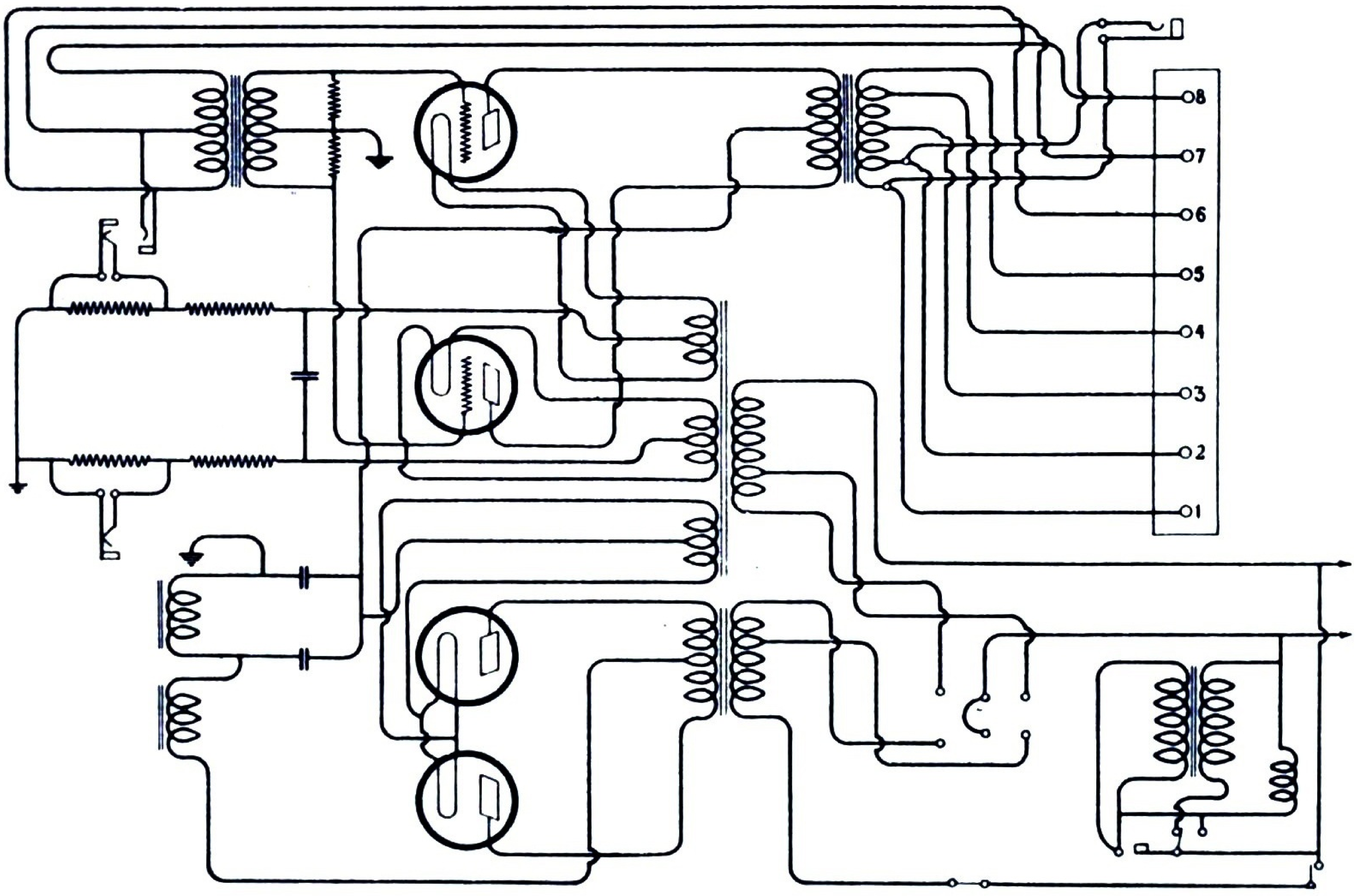


FIG. 15. Power amplifier circuit

amplifier located in the basement amplifier room. This amplifier supplies fifty-three magnetic loud speakers of the wall type located in the various dressing rooms, offices, rehearsal rooms, cafeteria, *etc.* By means of this system, announcements may be made and performers called. When the microphone is not being used, the call system "floats" on the public address system so that persons in any of these rooms are aware of what is happening on the stage.

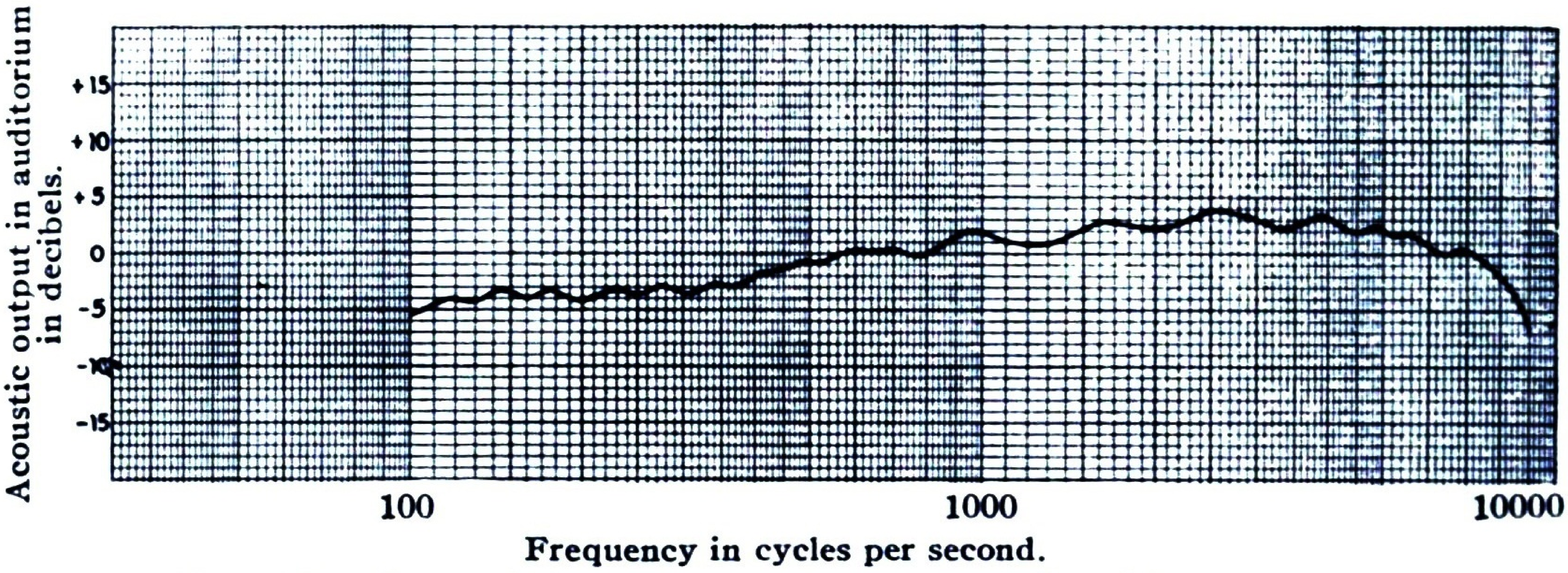


FIG. 16. Over-all frequency response; public address system.

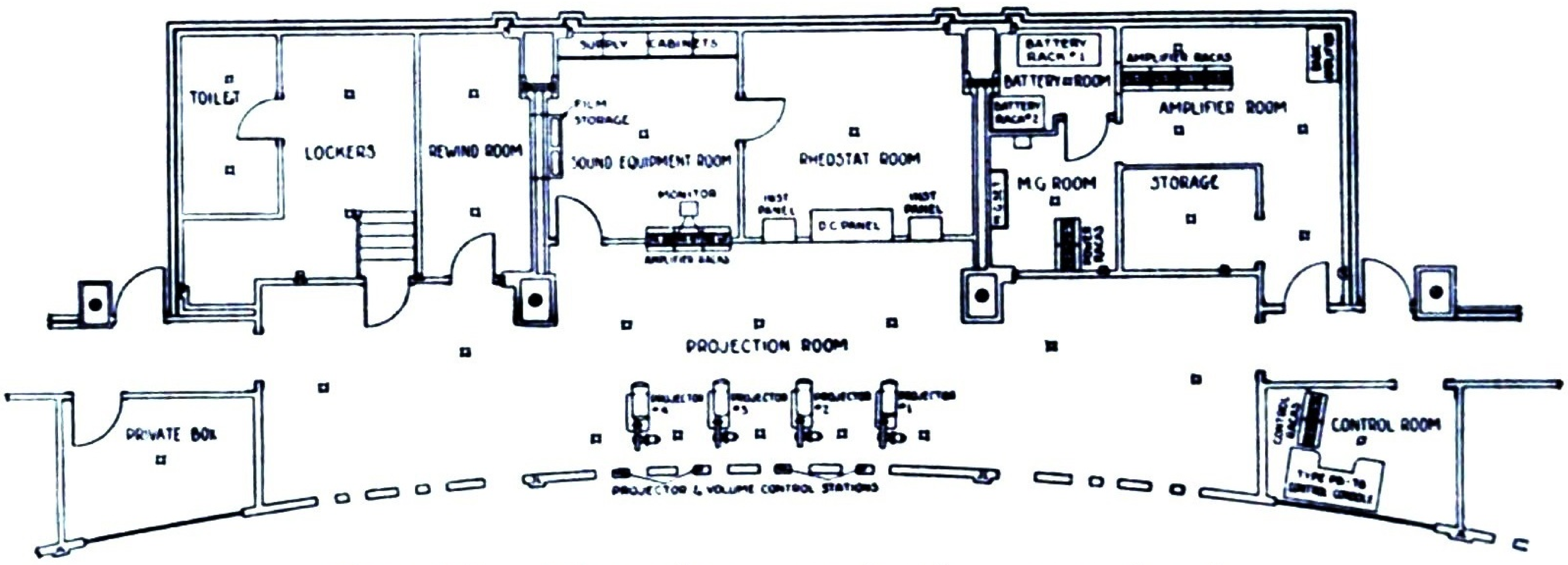

TOILET
LOCKERS
REWIND ROOM
SUPPLY CABINETS
FILM STORAGE
SOUND EQUIPMENT ROOM
MONITOR
AMPLIFIER RACKS
RHEOSTAT ROOM
INST PANEL
D C PANEL
INST PANEL
BATTERY RACK #1
BATTERY ROOM
BATTERY RACK #2
AMPLIFIER RACKS
AMPLIFIER ROOM
M.G ROOM
STORAGE
PROJECTION ROOM
PRIVATE BOX
PROJECTOR #4
PROJECTOR #3
PROJECTOR #2
PROJECTOR #1
PROJECTOR & VOLUME CONTROL STATIONS
CONTROL ROOM
TYPE PD-70 MIXER CONSOLE

FIG. 17. Plan view; projection room level.

An emergency key is also supplied with the microphone, which enables the operator to connect the call system amplifier into the circuit of the auditorium public address loud speakers for making emergency announcements to the audience.

Lines are provided between all amplifier racks and between racks and the mixer console so that a very flexible and efficient system results. Any amplifier may be used as a standby for any other. Microphone output, "effects," film phonograph, or projector output, may be patched into any of the systems at will; any system may be coupled to the loud speakers normally operated by another system, *etc.* A plan view of the main projection room level, Fig. 17, shows the location of most of the equipment described so far.

The radio-frequency distribution system used to supply carefully shielded broadcast signals to radio receivers consists of a single, almost vertical, antenna wire feeding an a-c. operated radio-frequency amplifier located in a fan room near the roof. This amplifier increases the signal level and lowers the line impedance so that the signal may be fed down a specially constructed, low capacity, shielded cable to the various radio receiving channels in the building. At these points, coupling transformers increase the impedance to a value suitable for the input of a radio receiver. This system allows the use of a single antenna for several receivers and assures a signal free from "noise" pick-up within the building.

The custom built dial radio and monitoring system consists of a basic amplifier and control cabinet, located on the projection room level, controlled by telephone dials located at remote points, such as an executive office and an executive dining room. At these points, loud speakers are built into the walls behind ornamental grilles. At one location, an automatic record-playing mechanism is recessed into the wall. This machine will play a large number of records without requiring any attention after the initial loading of the magazine. If any selection is not liked, dialing a number instantly rejects that record and the machine passes to the next record.

Instant selection of twenty radio stations is assured, and the stage program or sound picture reproduction may also be heard. A high-quality radio receiver is the heart of the system. It is operated by the dial selectors of the same type as those used in automatic telephone exchanges.

One difficulty peculiar to this particular theater which was overcome is worth reviewing. As shown in Fig. 7, the stage consists chiefly of elevators, three of which are rectangular elevators having a rotatable section in the center made up of parts of the three elevators. In addition, there is an orchestra pit elevator.

To connect the microphones to these elevators for public address purposes was a relatively simple problem, which was solved by using "swing" cables beneath the elevators. However, the musicians comprising the orchestra sit in a motor-driven structure known as the "bandwagon." This can travel anywhere from its "garage" located under the first ten or twelve rows of seats to as far back as the rear stage elevator (see Fig. 18). It can be moved below stage out of sight if all the elevators are lowered (this necessitates raising a steel "curtain") or it can be raised and moved across the footlights, which sink into the floor, back to either the first or third elevators, where it can be lowered and returned to the garage out of sight. An alternative, sometimes made use of, is to stop the cycle and reverse it. Maintaining connections to seven microphones on this "bandwagon" was a difficult problem.

The problem was solved by using two cable receptacles on the "bandwagon" connected in multiple. Outlets were provided on the elevators and in the garage. Extension cables were used and whenever the "bandwagon" moves from one position to another, a second extension cable from the new position is plugged into place while the cable from the first location is still connected. Then the latter cable is removed. This is performed behind the "bandwagon" out of sight of the audience, while the "bandwagon" may be moving. In this way, continuous contact is maintained, and the orchestra may be picked up, amplified, and reproduced for the audience while it is below stage on the elevators moving to a new position.

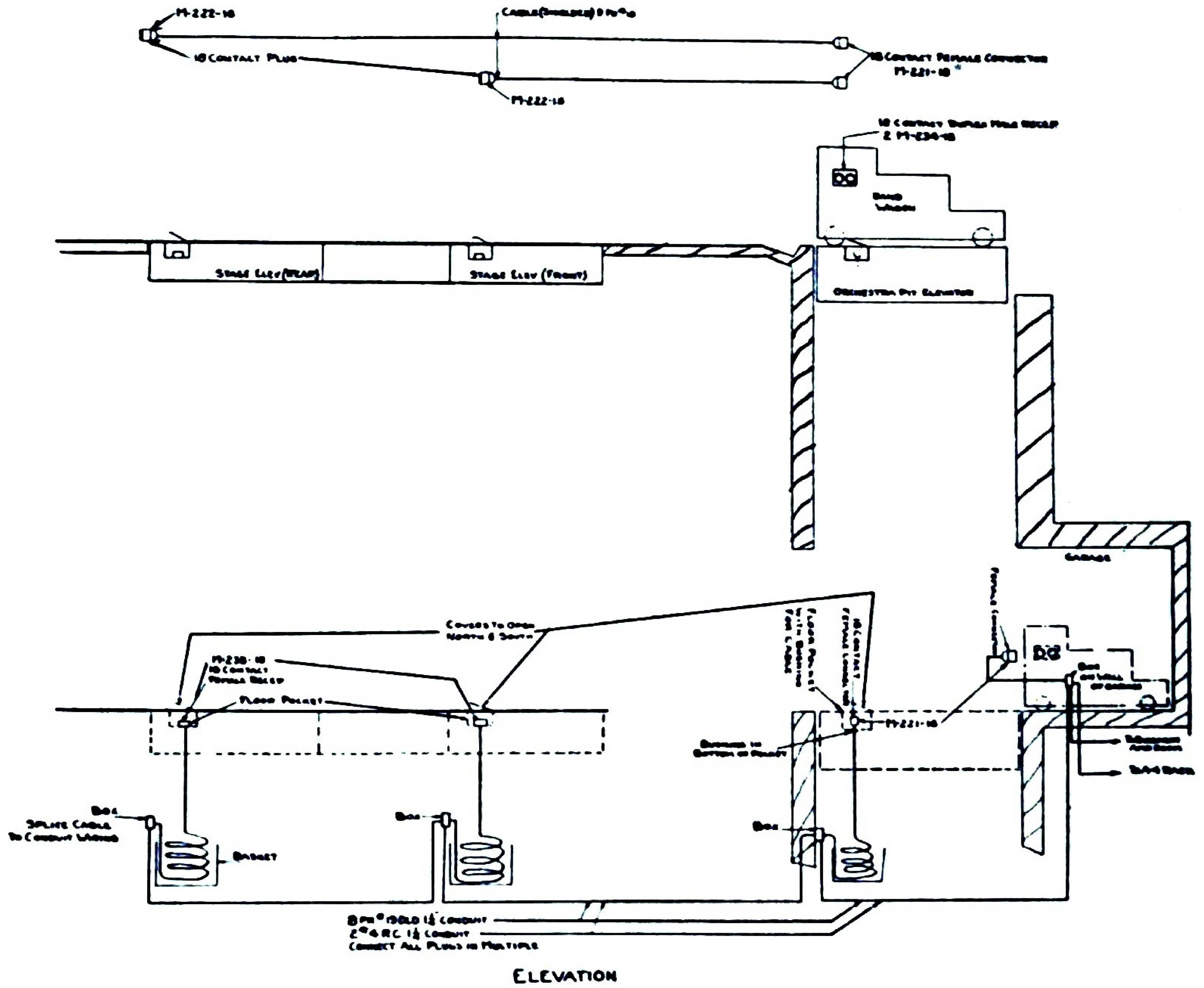

M-222-10
10 Contact Plug
M-222-10
10 Contact Female Connector
M-221-10
Band Wagon
Stage Elev (Rear)
Stage Elev (Front)
Orchestra Pit Elevator
Garage
Covers to Open North & South
M-230-10
10 Contact Female Recep
Floor Pocket
Box
Splice Cable to Conduit Wiring
Basket
Box
Box
M-221-10
Connect All Plugs in Multiple
ELEVATION

FIG. 18. Stage elevators and "bandwagon."

The author wishes to acknowledge the great amount of help received in installing this equipment from Mr. G. A. Toepperwein of the RCA Victor Engineering Department who completely engineered and planned the project, from Messrs. Cochran and Lehman of the same department, who are responsible for a great deal of the apparatus design, and to Mr. Harry Braun who was responsible for the installation of equipment at the RKO Roxy Theater and who rendered valuable assistance in this installation.

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[1] OLSON, H. F.: "Recent Developments in Theater Loud Speakers of the Directional Baffle Type," *J. Soc. Mot. Pict. Eng.*, **XVIII** (May, 1932), No. 5, p. 571.

[2] OLSON, H. F.: "The Ribbon Microphone," *J. Soc. Mot. Pict. Eng.*, **XVI** (June, 1931), No. 6, p. 695.

DISCUSSION

MR. FRANK: The installation in the Radio City Music Hall cost something in the neighborhood of $75,000, including supervision of the installation, but not the electrical work connected with the installation.

MR. RICHARDSON: That, as I understand it, includes only the projection equipment?

MR. FRANK: Only the sound equipment, not the projectors or arc lamps.

MR. KREUZER: It does, however, include the public address equipment and the reinforcing.

MR. BLIVEN: Is there any correction from the center of the house?

MR. KREUZER: There has been no correction due to the fact that the house is usually dead beyond the center.

MR. BLIVEN: I noticed that if one listens at the center he can hear the voices from the stage as well as from the public address system. Is the microphone set-up responsible for that?

MR. KREUZER: It is possible that the set-up of the next scene behind the stage might have influenced the set acoustics at the time. I have occasionally observed that if the stage is entirely bare and the performance is going on directly in front of the large curtain, there is a rather large volume back stage, and it is possible to get a small amount of vibration from the white tiled walls. I think that could be prevented.

I can not verify your observation from my own experience, but I can say with the sound coming from the actors on the stage, it might well happen. We have made tests, and found that on most locations 100 per cent of the sound comes from the public address system.

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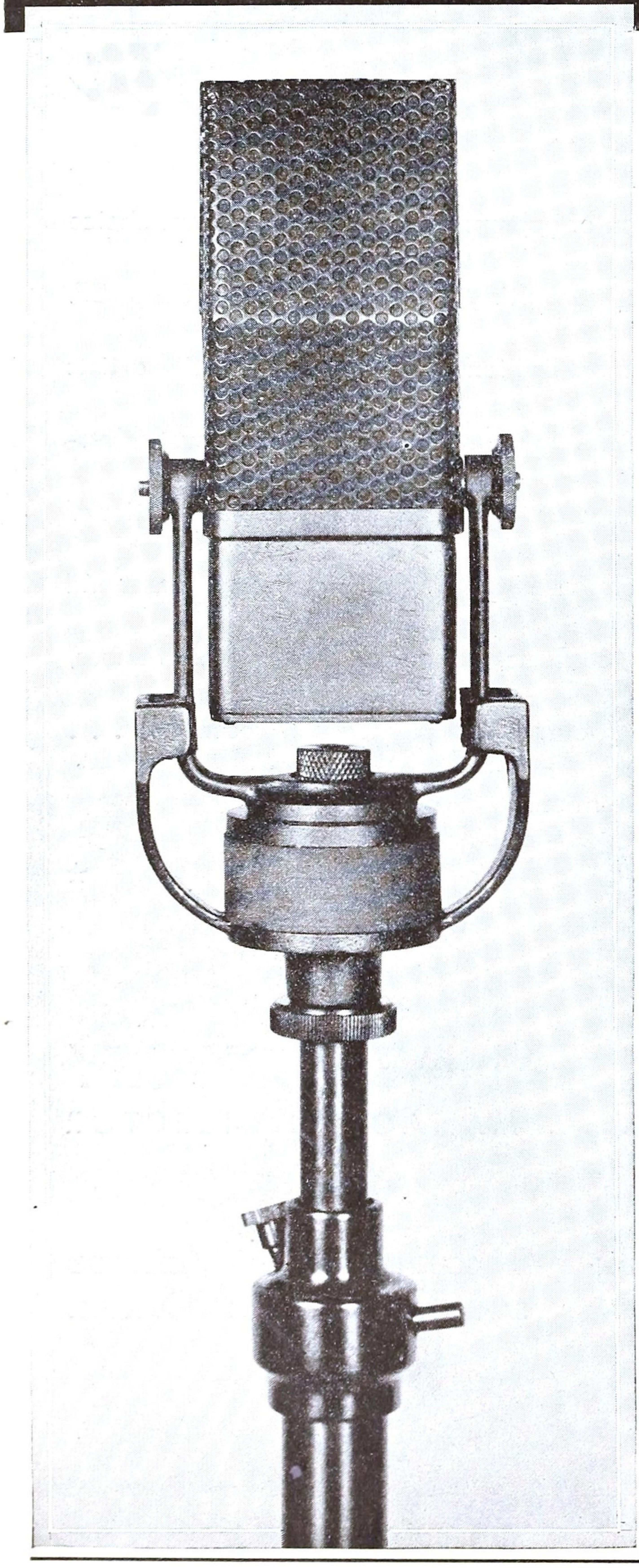
RCA Victor VELOCITY MICROPHONE

"THE MICROPHONE WITHOUT A DIAPHRAGM"



VELOCITY ACTUATED!

Most microphones (all those using a diaphragm) are subject to pressure-doubling and hence accentuate certain of the higher frequencies. The VELOCITY MICROPHONE avoids this because it is not a pressure-operated device. Its moving element is a light metal ribbon which vibrates at a velocity proportional to the velocity of the sound wave. Unlike a pressure-operated diaphragm, this ribbon element has no resonant frequency in the audible range . . . hence does not accentuate any notes . . . and does not require a compensated amplifier.

WIDER FREQUENCY RANGE!

The e.m.f. generated by the ribbon element is proportional to the velocity of the sound wave. Since this velocity is independent of the frequency, the response of the VELOCITY MICROPHONE is nearly uniform over a range extending from 30 cycles to beyond 14,000 cycles.

GREATLY IMPROVED FIDELITY!

Old-style microphones presented an impeding surface to sound waves which set up reflections and caused cavity resonance with consequent humps in the frequency characteristic. The VELOCITY MICROPHONE does not—it is open—the sound waves penetrate it freely. Because there are no peaks whatever in its response, it reproduces with perfect fidelity every note of the program presented before it.

DIRECTIONAL CHARACTERISTIC!

The VELOCITY MICROPHONE has very marked directional characteristics (entirely independent of frequency) which greatly facilitate pick-up of desired features and elimination of extraneous noise. However—since it is bi-directional—it actually provides greater space for artists.

INCREASED PICKUP!

The energy response of this microphone to reflected sounds is only one-third that of non-directional (diaphragm) microphones. Since the ratio of direct to reflected sounds determines the distance of satisfactory pickup, this microphone may be used at distances 1.7 times those for other types of microphones of the same sensitivity.

LOW IMPEDANCE!

The impedance of the VELOCITY MICROPHONE is low. This eliminates inductive pickup and makes possible location at a distance from the amplifier with resulting increase in convenience and decrease in amplifier cost.

ENGINEERING PRODUCTS DIVISION

RCA Victor Company, Inc.

A Radio Corporation of America Subsidiary

CAMDEN, N. J. "RADIO HEADQUARTERS"

REPRODUCTION IN RADIO CITY THEATRES

By JAMES FRANK, Jr.

Describing in detail the complete installation of sound systems in the music hall and the cinema located in Rockefeller Center

THE CITY in a city now rapidly nearing completion in New York City and to be known as Rockefeller Center, is to include two theatres, the larger to be known as the "International Music Hall," with a seating capacity of 6,300 seats, the smaller to be called the RKO Photoplay Theatre and having a seating capacity of 3,000 seats.

These two theatres are being equipped by the RCA Victor Company, Inc., with sound systems embodying the highest standards of electrical and mechanical design. The equipment was selected after a careful study of the plans and specifications of these theatres. The operating and control features have been designed to facilitate ease of control, and provision has been made for selection of alternative circuits and amplifiers.

The equipment consists of standard RCA Victor sound reproducing apparatus especially assembled for this installation and of somewhat greater power than it is customary to furnish for theatres. The installation for International Music Hall is larger and covers a wider scope. It has a total undistorted output of 510 watts. The sound systems to be installed in the larger theatre are divided into eight units—*sound reinforcing system, rehearsal address system, stage manager's call system, main sound projection system, rear stage sound projection system, deaf headphone system, preview sound projection system, and radio and monitoring system.*

The installation of these systems is to be so arranged that through physical location and electrical connection certain of the equipments may be inter-connected. *Figure* 1 shows the equipment layout on the projection room level. From the diagram the various amplifiers and sound reproducers may be easily located. Further reference will be made to this diagram under the description of the different systems.

It is important to note that the amplifiers and loudspeakers used on the various systems are essentially alike, although various assemblies of apparatus are employed.

I

Sound Reinforcing System

THE PURPOSE of this system is to reinforce the stage presentations and orchestra music to suitable levels in order that the desired aesthetic effects and clear intelligibility may be obtained at all points in the auditorium. This system consists essentially of a number of microphones, amplifier equipment and loudspeakers, together with necessary control apparatus. The microphone transmitters located around the stage and orchestra pit pick up the voices or music, change the sound waves to electrical waves, which are fed into the microphone amplifiers. After the level has been raised by these units the electrical waves are fed into the mixers in the control console, where they are properly mixed and then fed into a "booster amplifier." At this point the level is sufficiently raised to feed into the main amplifiers. From the main amplifier the electrical waves, now at any desired level, are fed into the auditorium loudspeakers, where they are converted into sound waves again which are directed to all points in the auditorium. Intricate control apparatus is employed to properly operate this system.

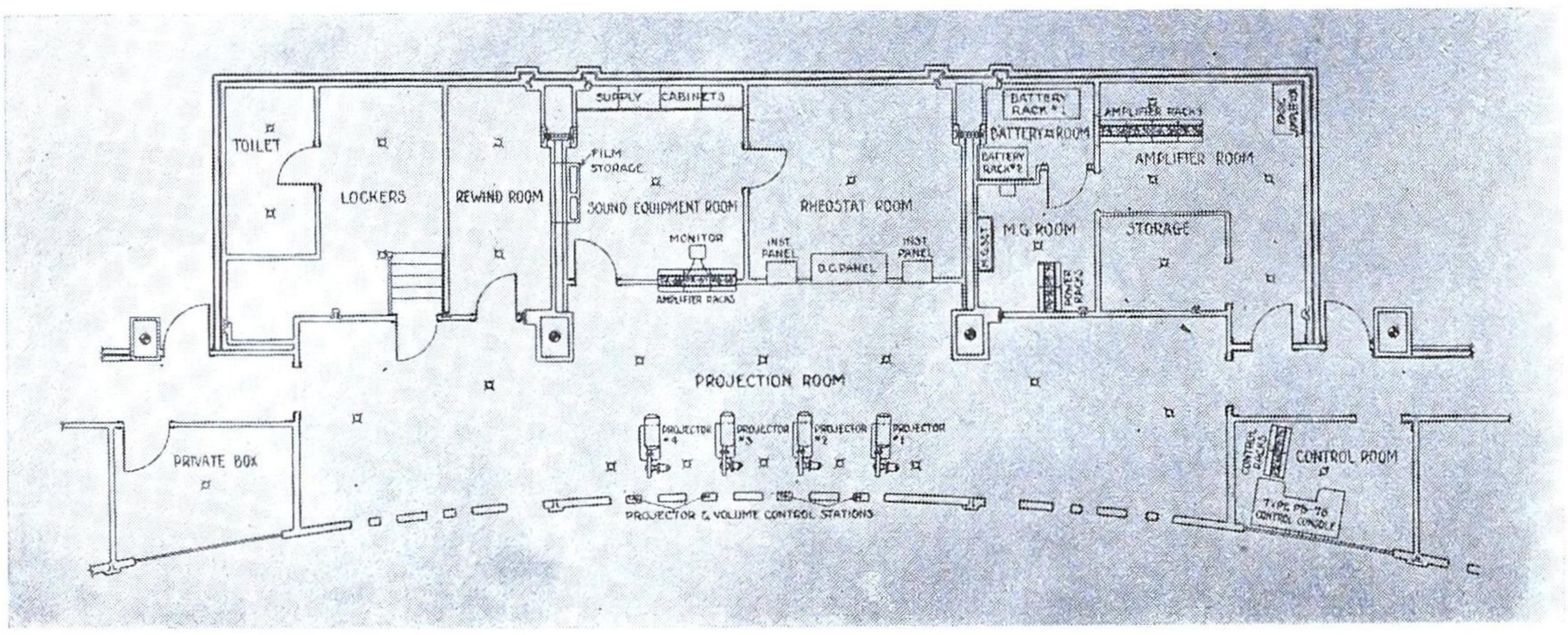


Figure 1.—*Apparatus layout on the projection room level.*

Fifty Type PB-31 velocity microphones of the kind used for sound recording will be furnished, mounted on swivel bases in order that they may be "aimed" in any desired direction. These microphones will be located as follows:

VELOCITY MICROPHONES

Eight microphones in traps in the floor of the orchestra elevator. Eight on program stands on band wagon. Eight suspended from light bridges. Eleven in footlights approximately on 7-foot centers. Nine on stage connected to traps on the stage floor. Six (three on each side) on choral stairs.

The velocity microphone contains a thin metallic ribbon suspended between the poles of a permanent magnet in place of a "diaphragm." Sound waves reaching the ribbon vibrate it within the magnetic field set up by the magnet. The sensitivity of the velocity microphone is approximately 2½ times that of a condenser microphone generally used. This makes possible an increased operating range. The microphone responds very faithfully to all sound vibrations over the range of audible frequencies from 30 to above 10,000 cycles. This is due principally to the smallness, the size and mass of the ribbon element placed in the free space. The faithfulness of response of this microphone imparts a naturalness of tone and a distinctness of speech not hitherto attainable with other units.

The most important characteristic of the velocity microphone is its directional property. Since the ribbon is suspended in free space, sound waves approaching the microphone from a direction on the same plane as the ribbon have no effect upon it, but sound waves from either direction along an axis perpendicular to the plane of the ribbon, have a maximum effect. For equal distances from the transmitter, sound originating 70° or 80° off of the axis perpendicular to the ribbon will have practically no effect, whereas at 45° off of this perpendicular, the sensitivity is approximately 70% of the maximum. This characteristic is of great value in the solution of some of the difficulties usually encountered in reverberant locations by the reduction of the effect of undesired sound reflections, and in the increased possibilities of obtaining better balance and selectivity in sound pickup. In addition, this characteristic is likewise outstanding in that this is the only type of microphone that responds uniformly to all audible frequencies over the entire 45° angle. This permits placing microphones in the footlights on approximately 7-foot centers, with the result that uniform pickup of all frequencies is accomplished across the front of the stage.

Another advantage of the velocity microphone is its uniform operation independent of changes in climatic conditions, such as atmospheric pressure, humidity, or temperature, any or all of which considerably affect other types of microphones. The velocity microphones are designed for suspension, program stand, or footlight mounting.

AMPLIFIERS

Fifty microphone amplifiers will be required. These amplifiers will be located on a specially constructed rack located in an amplifier room in the basement under the stage. The amplifier is carefully shielded to render it free from external interference and undesired pick-up. The entire unit is enclosed in a cylindrical metal case particularly designed for wood rack mounting, and is mounted vertically with connections made through plugs at the top and bottom. Power supply to operate the unit is made available from the amplifier room on the projection room level.

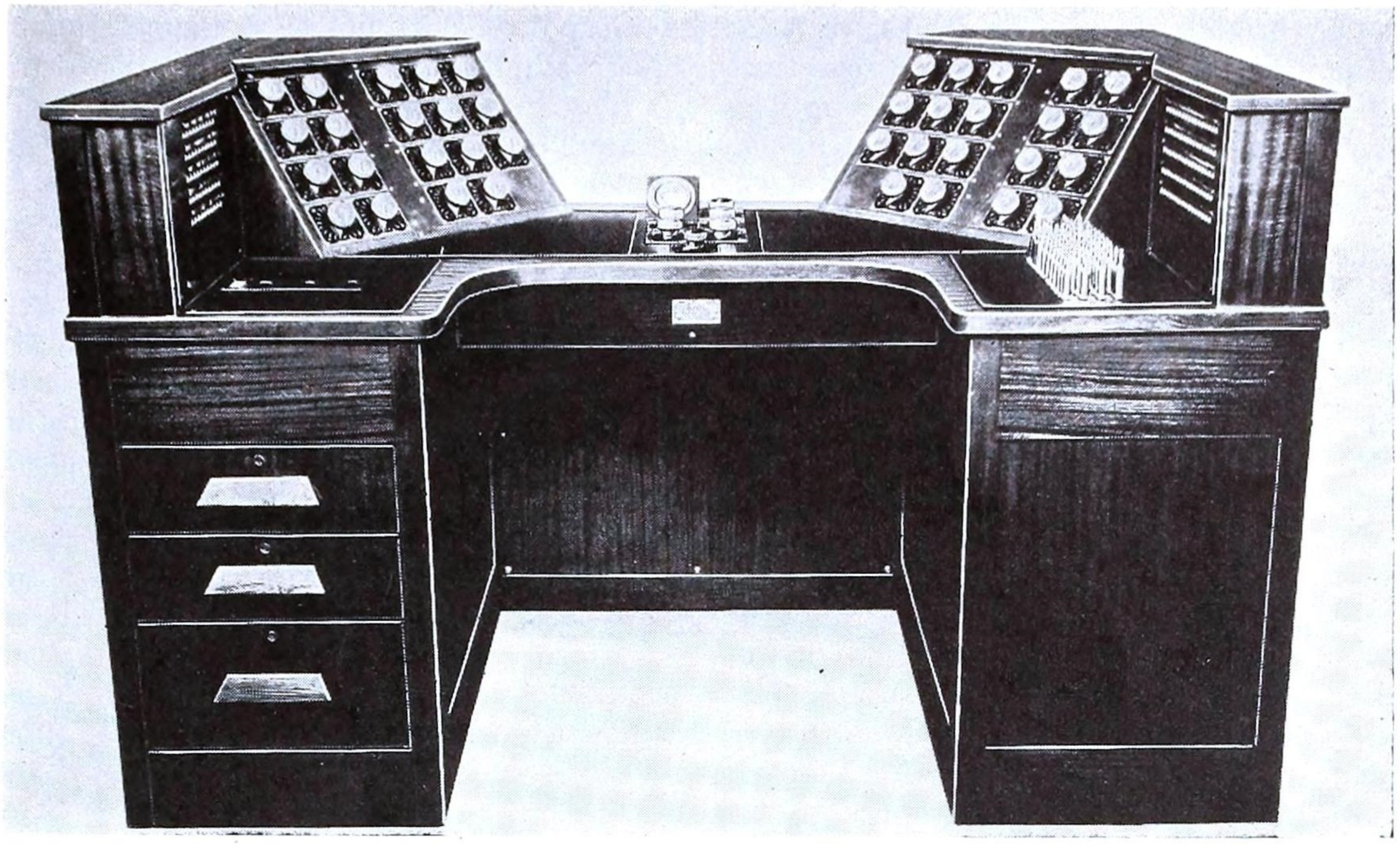


Figure 2.—*The control console.*

A control console (illustrated in *Figure* 2) is to be furnished for controlling the individual microphone amplifier outputs and mixing them properly for amplification. It is located in the control room (as shown in *Figure* 1). The console is of the mahogany desk type with metal top, on which all the controls are located. At the front right side of the console is located an 80-jack panel, at which point the outputs from the 50 microphone amplifiers terminate. The additional jacks not accounted for are for expansion. Directly in front of the jack panel are 38 cords and single plugs with weights and rollers divided into four groups, two of eleven each, and two of eight each, each group with a distinctive color. The cords are arranged in four rows.

At the back right and left side of the console are located four mixers, two 11-position mixers, and two eight-position mixers, each with its distinctive color on the mixer knob and wired to its respective cords mentioned above. On the console top a four-position mixer is located, one position for each of the above mentioned mixers, which controls the level of its respective group. By plugging the plugs into the jacks, any combination of microphones, with a maximum of 38, in groups of eight or 11, may be selected and mixed in the four mixers. After this operation, the output of each of these four mixers is fed into the four-position mixer. A master mixer is located on the console top, which controls the mixed output of the four-position mixer. At the front left side of the console top, a "booster amplifier" is located, which compensates for the loss in the control console. The output from the master mixer is fed into this amplifier, and the level is raised to such an extent that the output can be coupled to the main amplifier.

A volume indicator is mounted on the console top at the rear in a vertical position. An adjustment is supplied so that a predetermined reading on the meter may be made to represent any output level of the amplifier.

At the front left side of the console is located a jack panel for changing normal connections of the outputs of the eight-position and the 11-position mixers into the four-position mixers, to prevent the failure of one unit of the four-position mixer from interfering with the operation of the system. In case of emergency, it is also possible to circumvent the four-position mixer, and/or the "booster amplifier" to feed directly into the main amplifier at a reduced output. The separate control units of the mixers can be removed for repair at a moment's notice, such removal not affecting the operation of the remaining units.

The main amplifier equipment consists of two duplicate 80-watt amplifier channels, Type PB-84. These amplifiers are primarily arranged for operating in duplicate; that is, one at a time, the other being held in reserve for emergency use. However, provision has been made so that one channel may be used on the regular sound reinforcing system, and the second channel used at the same time to operate the effect loudspeakers. These amplifiers consist of units mounted on standard channel-iron racks and are located in the amplifier room (see *Figure* 1). Each of the channels include necessary terminal strips, main power line switch, a Type PB-23 voltage amplifier unit, two Type PB-45 power amplifier units (40 watts each), and a Type PB-24 power amplifier unit (10 watts). All amplifier units are complete in themselves in that they contain their own a.c.-operated power supply apparatus.

The 10-watt power amplifier unit is used for the deaf headphone system. The output impedance is such that a variable number of headphones may be installed. All headphones are connected across the output of the amplifier in series with an adjustable resistor of sufficiently high value that all headsets may be removed from their jacks without affecting the frequency characteristic of the system.

The Type PB-50 miscellaneous equipment rack, which is located with the main amplifier, includes an audio relay panel, two jack panels, a Type PB-51 tube testing panel, a radio receiver, a phonograph turntable, an amplifier unit.

The audio relay panel includes the relays required to switch the deaf hearing system amplifier to either the sound reinforcing system or the main sound projection system, to switch either of the sound reinforcing system amplifier channels into the circuit, and to connect the stage manager's call system to the sound reinforcing system when desired.

The two jack panels are used for "patching" or "interconnecting." The input and output circuits of all amplifiers on the sound reinforcing system, rehearsal address system and stage manager's call system are brought out to these panels, as well as the outputs of all special apparatus including radio receiver, phonograph turntable, and the like. For normal operation no cords are required, but for special interconnection or for use of special apparatus, cords tying the desired circuits are used in these jack panels.

The tube testing panel is designed to test all tubes and tube circuits employed in the amplifier and power racks. The radio receiver is a nine-tube Superheterodyne which will work in conjunction with any of the power amplifier units in the system. It is connected to the Antenaplex system described in the radio and monitoring system.

The amplifier unit included in this rack is used for monitoring purposes. This unit may be connected across the output of the power amplifier unit of either the sound reinforcing system, effect system (one channel of sound reinforcing system), stage manager's call system, or the rehearsal address system, and will operate the monitor loudspeakers on the Type PB-60 power control rack, in the amplifier room, in the spot cove, or at the chief electrician's position.

The Type PB-60 power control rack, located adjacent to the control console in the control room, includes a microphone power control panel, an amplifier power control panel, a rehearsal microphone mixer, an audio control panel, a monitoring loudspeaker panel, and a chief electrician's microphone control panel. The microphone power control panel includes switches which, through the use of relays, turn on the power to all microphone transmitters and microphone amplifiers. The amplifier power control panel includes switches, which similarly through the use of relays, turn on the power to all the amplifiers used in the sound reinforcing system and rehearsal address system.

The rehearsal microphone mixer includes mixer units for controlling the output of each of the four microphones used on the system, with a master mixer to control the group.

The audio control panel includes two key switches, one to select, through the use of relays, amplifier channels for this system and the other to connect, through the use of relays, the deaf hearing system amplifier to either the sound reinforcing system or the main sound projection system. In addition, four remote volume control push button stations are included, controlling the volume on each of the amplifier channels of the sound reinforcing system, and of the rehearsal address system. The monitoring loudspeaker panel includes a panel-mounted electro-dynamic loudspeaker unit with volume control.

The chief electrician's microphone control panel consists of a control unit to equalize the output of the carbon microphone used by the chief electrician on the rehearsal address system to the three microphones used on the same system.

The Type PB-76 loudspeaker control rack is located also adjacent to the control console in the control room. It includes two sound reinforcing loudspeaker control panels and two rehearsal loudspeaker control panels.

The Type PB-56 power supply rack, which is located in the motor-generator room, includes an a.c.-relay panel, two d.c.-relay panels, and two plate and bias supply units. The a.c. panel includes a number of relays to connect the a.c. supply to the rectifier tubes. The two d.c. panels include a number of relays to connect the power supply to the microphones of both the sound reinforcing system and the rehearsal address system. The two plate and bias supply units are connected in duplicate, one being used regularly and the other as emergency, and are used to supply plate and bias power to the microphone amplifiers and the "booster amplifier." The unit is designed to operate from a 205-220-volt, 3-phase, 60-cycle a.c. supply. It is essentially a 3-6 phase rectifier. This unit reduces the percentage of a.c. ripple voltage in the d.c. output voltage of the rectifier tubes. This is a distinct advantage over the common one- and 2-phase rectifiers, in that less filtering is required at 360 cycles to reduce the percentage of ripple voltage to any predetermined level, than at 120 cycles. This reduction in required filtering improves the regulation of the rectifier in that the series resistance factor of filter inductances is reduced to a minimum. The regulation of the rectifier is further helped by the use of a mercury vapor rectifier, because the voltage drop in this tube is practically constant for any load within the tube rating. These factors are very important because of the fact that this rectifier supplies plate power to several microphone amplifiers.

The Type PB-79 power supply rack is located adjacent to the PB-56 rack, and includes an a.c. relay panel, two Type PK-15 loudspeaker field supply panels, and two Type PK-20 loudspeaker field supply panels.

The a.c. relay panel includes a number of relays to connect the power to the amplifier of the sound reinforcing system, effect system and rehearsal address system. The two Type PK-15 loudspeaker field supply panels are used to supply power to the loudspeaker fields of the radio and monitoring system. Each panel delivers 0.5 amperes at 100 volts. The two Type PK-20 loudspeaker field supply panels are connected in duplicate, one being used regularly and the other for emergency, and are used to supply power to the fields of the sound reinforcing system and rehearsal address system loudspeakers. Each panel delivers 4.0 amperes at 100 volts.

The battery power supply equipment is all located in the battery room (see *Figure* 1). This equipment includes four sets of glass jar storage batteries together with charging equipment. A duplicate set of storage battery cells with a capacity of 1,040 ampere-hours is furnished to supply filament current to all microphone amplifiers and field supply to all velocity microphone transmitters of the sound reinforcing system and rehearsal address system. A duplicate set of cells with a capacity of 186 ampere-hours is furnished to supply excitation to all relays used with these systems. The cells are all mounted in racks against the wall.

A battery charging motor-generator set, together with control panel, starter, and necessary switches and conduit boxes, is also furnished. The sets of storage battery cells are so connected that one set of each type are in use when the duplicate sets are being charged.

Six loudspeakers are furnished for use on the sound reinforcing system in the auditorium, four Model 4PL35A1 loudspeakers and two Model 4PL35B1 loudspeakers. These loudspeakers consist of a directional baffle of the exponential type coupled to a 6-inch cone driver of rugged construction. This type of loudspeaker combines the advantage of a flat frequency characteristic with high efficiency, uniformity of response over the entire angle of distribution, and high power handling capacity. (*Figure* 3 shows one of these loudspeakers.

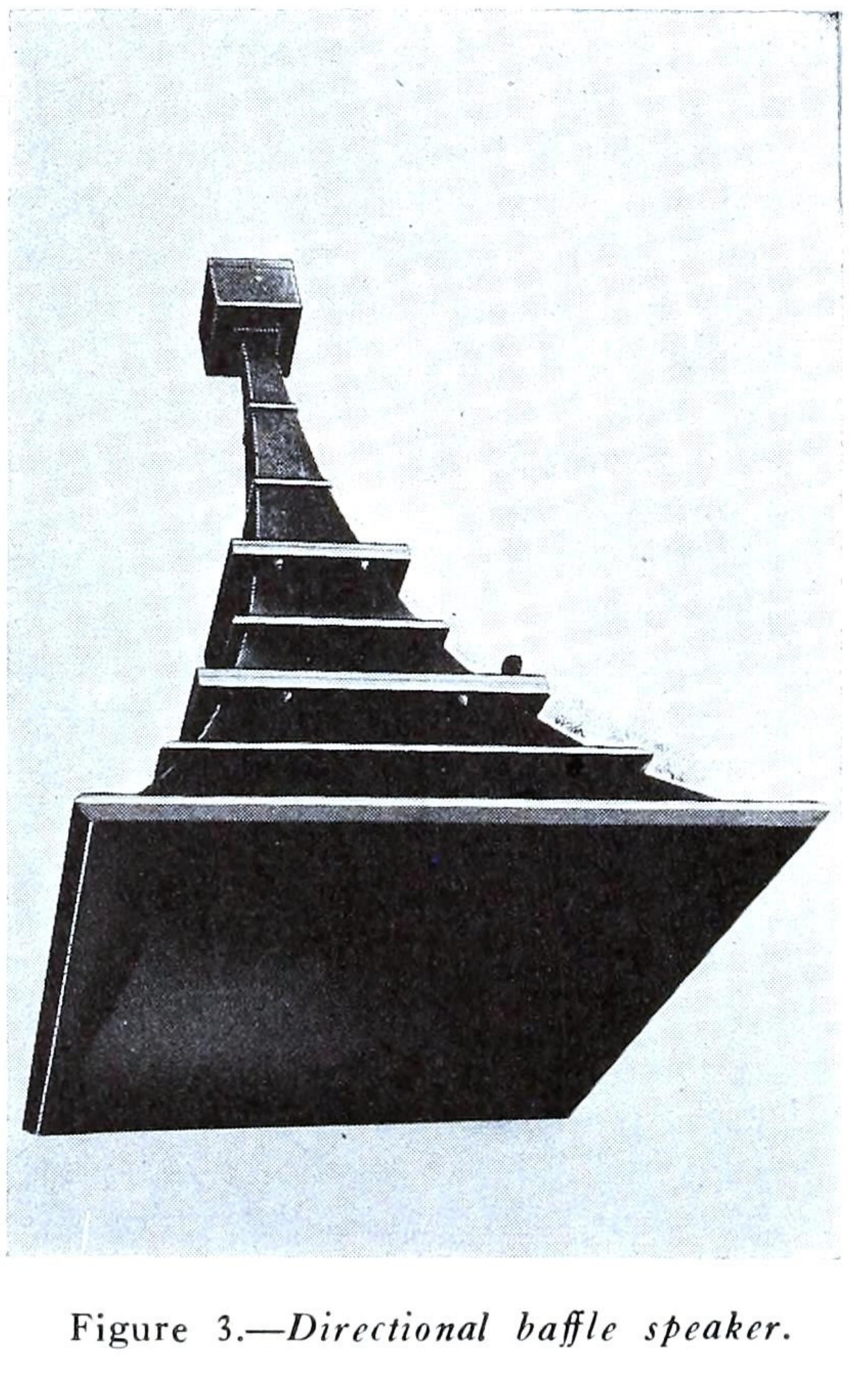


Figure 3.—*Directional baffle speaker.*

SPEAKERS

The four Model 4PL35A1 loudspeakers, employing 60-inch directional baffles, are to be mounted behind a grille above the proscenium arch. The two Model 4PL35B1 loudspeakers, employing 37-inch directional baffles, are to be mounted in the wall, one on each side of the proscenium.

For effect purposes two Type PL-64 loudspeakers, having 17-inch directional baffles, will be furnished for mounting at the rear of the stage over the rear stage projection room. These speakers may be connected to the second amplifier channel of the sound reinforcing system for simultaneous or separate operation when back stage sound effects are desired. Each directional baffle employs four of the six inch cone units.

For monitoring purposes, three Model AF6179 loudspeakers will be furnished, one to be located in the spot cove, one at the chief electrician's position, and one in the amplifier room. These loudspeakers consist of a standard magnetic speaker mechanism mounted in the rear of a specially designed wood plaque faced with three ply veneer and the center of matched oriental walnut.

The over-all frequency characteristic of the sound reinforcing system is such as to give uniform reproduction over a range of from 50 to 10,000 cycles.

II

Rehearsal Address System

THIS SYSTEM is to be used in connection with the execution of rehearsals of stage and orchestra presentations. It consists essentially of microphones located at definite positions feeding through amplifiers to a number of loudspeakers located to cover the stage, auditorium and various booths.

Three velocity microphone transmitters will be furnished mounted on stands, two of telescope stand type, and one of the desk stand type. One of these will be located on a desk, which will be placed in the 12th row of the orchestra floor during rehearsals. Another will be located in the director's private box located at the rear of the auditorium. The third is to be located in the control room. In addition, a carbon microphone announcing station, including necessary switches and pilot lamps, will be at the chief electrician's position.

Three microphone amplifiers will be furnished, one for each of the above mentioned velocity microphone transmitters. The amplifier for the transmitter at the

12th row of the orchestra floor, will be located in the amplifier room in the basement under the stage, where the amplifiers for the sound reinforcing system are located. The amplifier for the transmitter in the director's private box is to be located on the wall of the adjacent "spot booth," while the amplifier for the transmitter in the control room is to be located on the wall of that room. The main amplifier used for this system is similar to the one of the amplifier channels used on the sound reinforcing system. The rack is located adjacent to the main amplifiers of the sound reinforcing system in the amplifier room.

A large number of loudspeakers are used with this system to cover the auditorium, entire stage (including light towers), light control stations, and various spot and equipment booths. This equipment includes 25 speakers employing 37-inch directional baffles, and seven employing magnetic units on flat wood baffles. Through the use of these loudspeakers the director or anyone else at a microphone location may communicate with anyone in the theatre concerned with the rehearsal. This system may be used during regular performances, operating certain of the loudspeakers at low level.

III

Stage Manager's Call System

THE PURPOSE of this system is to provide means to the stage manager for conveying instructions and messages to stage employes and performers during rehearsals and performances. The equipment consists of a microphone at the stage manager's position, an amplifier, and a number of loudspeakers located in the employes' offices and all dressing rooms in the theatre.

A carbon microphone announcing station, complete with all necessary switches and pilot lamps, is to be located at the stage manager's position for "close talking" purposes. The main amplifier used on this system is similar in general design to those main amplifiers of the sound reinforcing system. This amplifier rack is to be located in the amplifier room in the basement under the stage.

IV

Main Sound Projection System

THIS SYSTEM consists of a duplicate channel, 80-watt, a.c.-operated sound reproducing system employing four soundhead attachments. This equipment is similar to the "standard" series of RCA Photophone reproducing equipment. The entire projection room equipment is finished in a specially selected green to match the balance of the projection room equipment.

Four Type PS-20 Simplex soundhead attachments are to be furnished with this system for mounting in the projection room (as shown in *Figure* 1). These attachments are to be mounted on Chicago Cinema bases with Super-Simplex mechanisms. The attachment is the same as supplied with "standard" Photophone equipment, except that 3-phase a.c.-motors are employed.

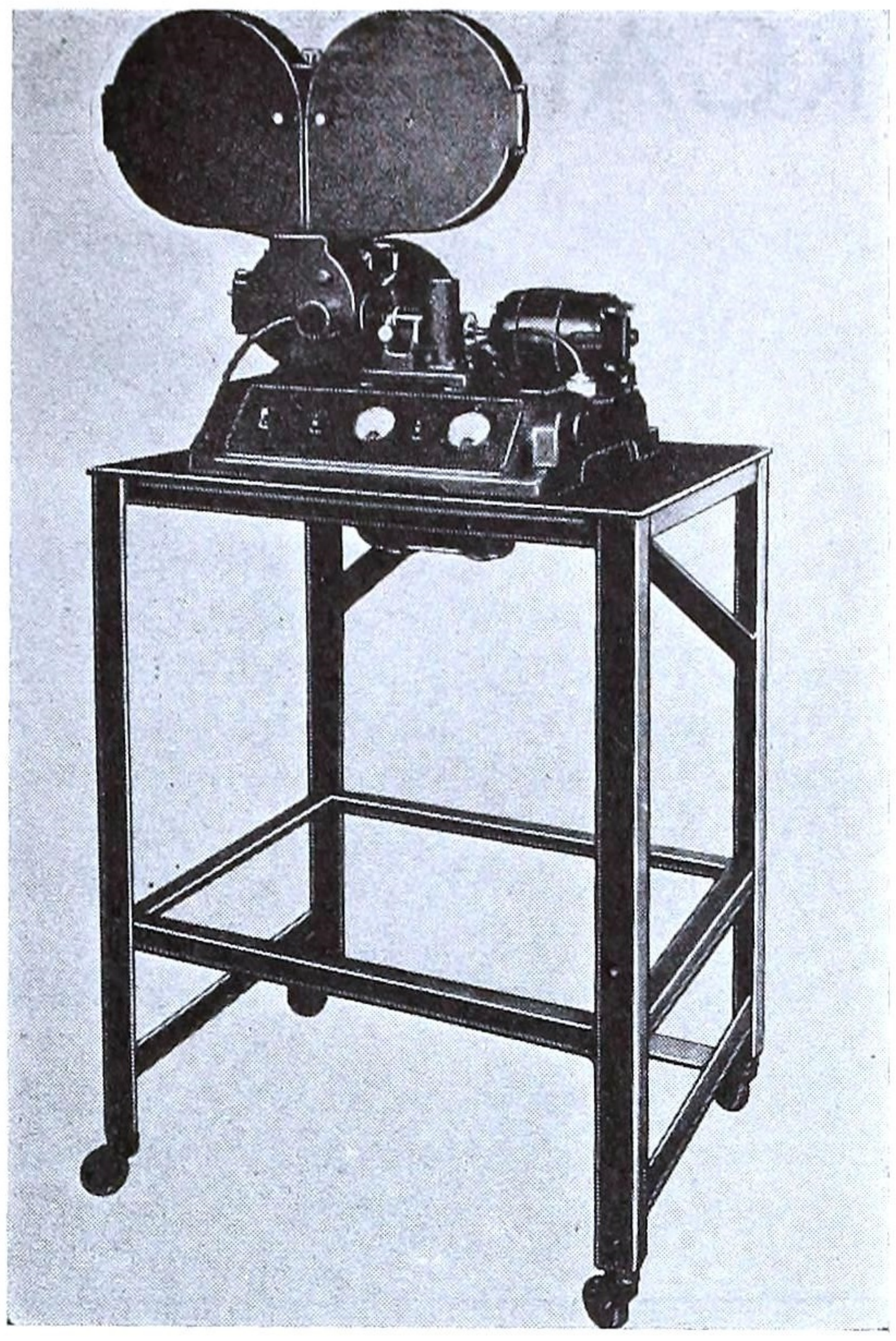


Figure 4.—*Film phonograph and phototube amplifier.*

A duplicate channel 80-watt main amplifier (Type PA-88 and Type PA-87) is to be furnished with this system. The voltage and power amplifier units are the same as those used on the sound reinforcing system. These racks are located in the rear wall of the projection room. All servicing is done from the front.

The PA-88 amplifier includes necessary terminal strips, main line power switch, a voltage amplifier unit, two power amplifier units (40 watts each), a jack panel, a dual channel switching panel, a projector changeover panel, and a loudspeaker field supply panel. The jack panel is to be used for "patching." By this means the main sound projection system may be interconnected with any of the other systems. The rear stage projection system is terminated at this panel and may be connected to the projection system by the use of patching cords. For normal operation no cords are required. The dual channel switching panel includes a switch with a knob mounted on it for switching from one amplifier channel to the other. The changeover panel includes a number of relays and pilot lamps to connect the output of any of the four projectors to the input of the correct amplifier channel. The loudspeaker field supply panel is of sufficient size to produce 0.8 amperes at 100 volts.

The PA-87 amplifier includes necessary terminal strips, main line power switch, a voltage amplifier unit, two power amplifier panels (40 watts each), a loudspeaker field supply panel, and a tube testing panel. The tube testing panel is the same in design and purpose as that supplied with the sound reinforcing system.

Fifty-six loudspeakers in this system will be located in the various dressing rooms, corridors, engineers' rooms, etc.

Forty-eight speakers employ a magnetic speaker unit on flat wood baffles, and eight employ a magnetic speaker unit on a double flat wood baffle, permitting distribution from the front and also from the back of the unit.

Alongside the duplicate amplifier channels, a power supply rack is to be located. This rack includes four exciter lamp panels and a monitoring amplifier unit. Each panel delivers 5 amperes at 10 volts. One exciter lamp panel is supplied for each soundhead attachment. The monitoring amplifier unit is similar to the one described in the sound reinforcing system and operates the monitor loudspeaker in the projection room.

Four fader and volume control stations are to be furnished for wall mounting, one in front of each projector, for fading the amplifier input to the proper soundhead attachment, and for controlling the volume of sound emitted by the loudspeakers. A remote volume control indicator consisting of 20 indicator lamps, which indicate the amplifier volume control setting, is to be furnished for wall mounting in the projection room. Five remote volume key control stations for mounting at various points in the auditorium are also to be furnished.

The stage loudspeaker equipment to be used with this system consists of three loudspeakers with 10-inch baffles, and three with 60-inch baffles. These speakers are similar to those supplied with the sound reinforcing system and illustrated by *Figure* 3. A speaker having a 37-inch baffle, with metal frame and mesh covering, is to be mounted in the rear wall of the projection room for monitoring purposes.

This sound system is all a.c.-operated. The over-all characteristic of the system is such as to provide for reproduction of all the audible frequencies from 50 to 10,000 cycles.

V

Rear Stage Sound Projection System

THIS SYSTEM is to be used for the projection of sound motion pictures from the rear of the stage to be used as background and for effects in conjunction with the stage presentations. It is all located in the rear stage projection room.

Two Type PS-20 Simplex soundhead attachments for mounting on Chicago Cinema bases with Super-Simplex mechanisms are to be furnished with this system. These attachments are the same as those supplied with the main sound projection system. The amplifier unit is designed to be connected to the input of the main amplifier of the projection system. The units are similar to those of the projection system except that the changeover panel provides for only two projectors.

A film phonograph will be furnished with this system (*Figure* 4). This unit is to be used for reproduction of a film record type of recording, either alone or in conjunction with a picture on a separate film. A phototube amplifier is to be furnished for operation with the film phonograph, to feed directly into the input of the

(*Continued on page* 34)

Reproduction in Radio City Theatres

(*Continued from page* 11)

main amplifiers of the projection system. The amplifier is mounted on the table of the film phonograph. A loudspeaker employing a magnetic unit on a flat baffle is used for monitoring purposes.

VI

Auxiliary Systems

Headphone System

PROVISION has been made for the installation of 26 outlets to be located under the arms of alternative seats in the thirty-third and thirty-fourth rows of the orchestra floor, into which Acousticon seatphone instruments may be plugged in order that those people who are hard of hearing may more clearly and intelligibly hear the sound motion picture and stage presentations. Each jack-box mounted under the arm of the chair includes two jacks for permitting the use of two instruments, one with each of the two adjoining seats. The amplifier for this equipment is located on the main amplifier racks of the sound reinforcing systems.

It is intended that individuals can obtain instruments at the box office upon request. Anyone who owns a private instrument designed for this particular use will be permitted to use it if he so desires.

Preview System

Two preview rooms located on the studio floor are to be equipped with sound projection systems. These systems are similar in general design to those furnished with the main sound projection systems, except that they have a smaller power output.

Radio and Monitoring System

The purpose of this equipment is to furnish to the private studios on the studio floor radio pickup of a predetermined number of radio stations and to permit the monitoring of the various sound systems in the theatre and for outside lines terminating within the theatre. This system will permit the following operations from each remote control station:

Starting and stopping of radio programs, choice of radio stations within range of the receiver, provision being made for 18 *stations, starting and stopping of record programs, rejecting of records, control of tone of both radio and record programs, control of volume of individual speaker locations of both radio and record programs, selections of programs from sound picture equipment and sound reinforcing equipment in both theatres and outside lines.*

All the operations will be controlled from telephone dials in accordance with simple code numbers.

The automatic cabinet phonograph will contain an automatic record-changing mechanism to play continuously 22 records of mixed tone and 12-inch commercial disc records. Provision will be included to play the records on one side, both sides, or repeat. The output of the electrical output will be amplified by the basic amplifier and reproduced by any set of loudspeakers. The cabinet and special plaques will be designed to conform in construction and material to the furniture selected.

The loudspeaker apparatus consists of three sets, the first of two electro-dynamic loudspeakers for flush mounting in the wall of the office, the other two of four electro-dynamic speakers each for flush mounting in the wall of each of the two studios. The basic amplifier and control equipment is a self-contained a.c.-operated unit consisting of a five-circuit radio receiver with provision for remote tuning of 18 predetermined radio stations.

VII

International Theatre System

The RCA Victor sound systems being installed in the "RKO Photopay Theatre" are similar to those to be installed in the International Husic Hall. The sound reinforcing system includes 20 velocity microphones, a duplicate channel 40-watt main amplifier, and four loudspeakers (60-inch baffles).

The rehearsal address system employs one of the velocity microphones supplied with the sound reinforcing system, which is placed in the twelfth row of the orchestra floor, and also uses the emergency channel of the main amplifier of the sound reinforcing system. This system includes five loudspeakers (37-inch baffles).

The stage manager's call system includes a "close talking" microphone announcing station, a 40-watt main amplifier, and 27 loudspeakers for distribution throughout the theatre.

The main sound projection system includes four Simplex soundhead attachments, a duplicate channel 80-watt main amplifier, a monitor loudspeaker, three loudspeakers with 10-foot baffles, and three having 60-inch baffles.

The deaf headphone system includes 52 Acousticon headphones and 26 jack boxes to be located in the thirty-third and thirty-fourth row of the orchestra floor. The amplifier unit is located on the main amplifier rack of the sound reinforcing system.

From this brief analysis it can be readily seen that the sound systems in the two theatres are very much alike, the one in the Cinema being smaller and not including a rear stage sound projection system, preview sound systems, or radio and monitoring.

These installations represent a modern application of sound reproducing equipment to theatre operation. They are particularly designed to allow for expansion and any future developments which may be introduced into theatre use. They are, without a doubt, the largest sound reproducing equipments ever manufactured for theatre installation, as, perhaps, is in keeping with the Radio City amusement project, the most comprehensive in the world.

Sound Systems in Rockefeller Center

By JAMES FRANK, JR.

THE city in a city now rapidly nearing completion in New York City and to be known as "Rockefeller Center," is to include two theatres, the larger to be known as the "International Music Hall," with a seating capacity of 6,300 seats, the smaller to be called the "RKO Photoplay Theatre," and having a seating capacity of 3,000 seats.

These two theatres are being equipped by the RCA Victor Co., Inc., with sound systems embodying the highest standard of electrical and mechanical design. The equipment was selected after a careful study of the plans and specifications of these theatres. The operating and control features have been designed to facilitate ease of control and provision has been made for selection of alternative circuits and amplifiers.

The equipment consists of standard RCA Victor sound reproducing apparatus especially assembled for this installation and of somewhat greater power than is customary to furnish for theatres.

The installation for the "International Music Hall" is the larger and covers a wider scope. It has a total undistorted output of 510 watts.

The RCA Victor Sound Systems to be installed in the larger theatre are divided into eight units, as follows:

1. Sound Reinforcing System.
2. Rehearsal Address System.
3. Stage Manager's Call System.
4. Main Sound Projection System.
5. Rear Stage Sound Projection System.
6. Deaf Headphone System.
7. Preview Sound Projecting Systems.
8. Radio and Monitoring System.

The installation of these systems is to be so arranged that through physical location and electrical connection certain of the equipments may be interconnected. Figure 1 shows the equipment layout on the projection room level. From the diagram the various amplifiers and sound reproducers may be easily located. Further reference will be made to this diagram under the description of the different systems.

It is important to note that the amplifiers, all of which employ standard Radiotrons, and loudspeakers used on the various systems are essentially alike although various assemblies of apparatus are employed.

1. Sound Reinforcing System

The purpose of this system is to reinforce the stage presentations and orchestra music to suitable levels in order that the desired aesthetic effects and clear intelligibility may be obtained at all points in the auditorium. This system consists essentially of a number of microphones, amplifier equipment, and loudspeakers, together with necessary control apparatus. The microphone transmitters located around the stage and orchestra pit pick up the voices or music, change the sound waves to electrical waves, which are fed into the microphone amplifiers. After the level has been raised by these units the electrical waves are fed into the mixers in the control console where they are properly mixed and then fed into a "booster amplifier." At this point the level is sufficiently raised to feed into the main amplifiers. From the main amplifier the electrical waves, now at any desired level, are fed into the auditorium loudspeakers where they are converted into sound waves again which are directed to all points in the auditorium. Intricate control apparatus is employed to properly operate this system.

Velocity Microphones

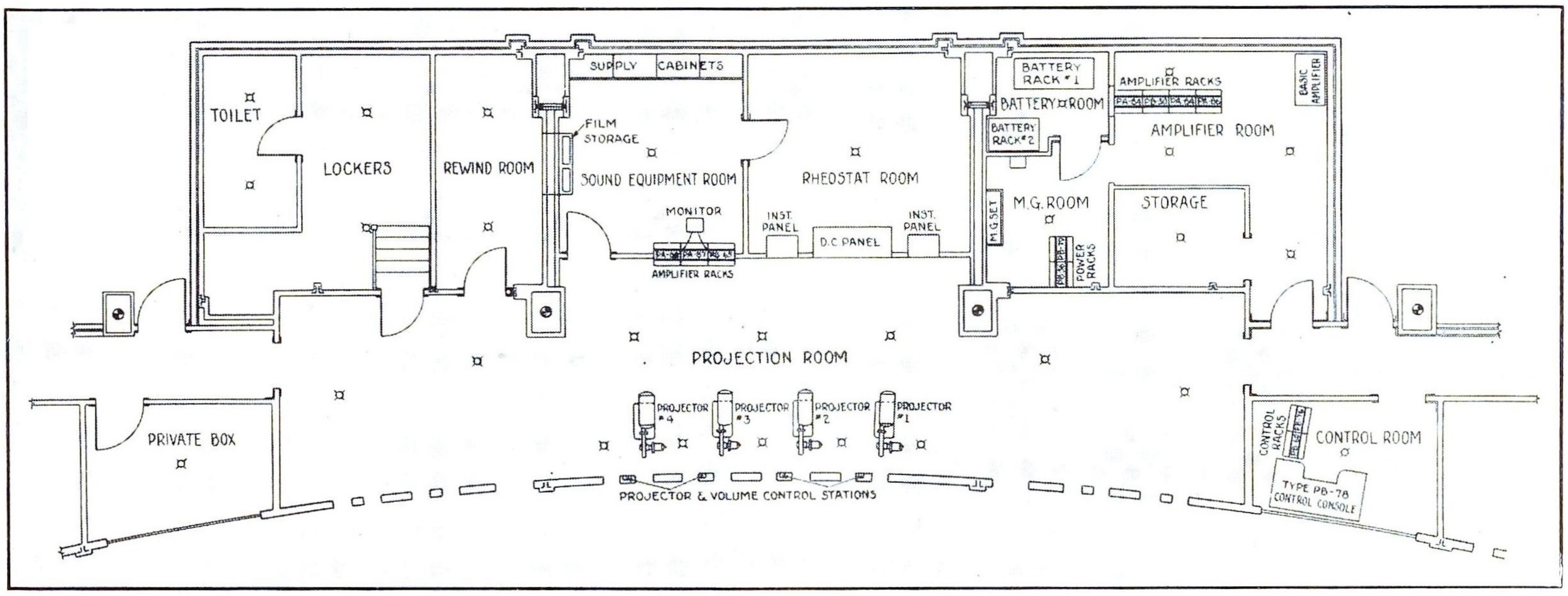
A. Fifty type PB-31 Velocity Microphones of the type used for sound recording are being furnished, mounted on swivel bases in order that they may be "aimed" in any desired direction. These microphones will be located as follows:

8 Microphones in traps in the floor of the orchestra elevator.
8 Microphones on program stands on band wagon.
8 Microphones suspended from light bridges.
11 Microphones in foot lights approximately on seven foot centers.
9 Microphones on stage connected to traps on the stage floor.
6 Microphones (3 on each side) on choral stairs.

The Velocity Microphone contains a thin metallic ribbon suspended between the poles of a permanent magnet in place of a "diaphragm." Sound waves reaching the ribbon vibrate it within the magnetic field set up by the magnet.

The Velocity Microphone has many advantages over any other type available. The sensitivity of the Velocity Microphone is approximately 2½ times that of a Condenser Microphone generally used. This makes possible an increased operating range. The microphone responds very faithfully to all sound vibrations over the range of audible frequencies from 30 to above 10,000 cycles. This is due principally to the smallness, the size and mass of the ribbon element placed in the free space. The faithfulness of response of this microphone imparts a naturalness of tone and a distinctness of speech not hitherto attainable with other units.

The most important characteristic of the Velocity Microphone is its directional property. Since the ribbon is suspended in free space, sound waves approaching the microphone from a direction on the same plane as the ribbon have no effect upon it but sound waves from either direction along an axis perpendicular to the plane of the ribbon have a maximum effect. For equal distance from the transmitter, sound originating 70° or 80° of the axis perpendicular to the ribbon will have practically no effect whereas at 45° off of this perpendicular the sensitivity is approximately 70% of the maximum. This characteristic is of great value in the solution



Layout of Projection Room in Rockefeller Center Theatres of some of the difficulties usually encountered in reverberant locations by the reduction of the effect of undesired sound selectivity in sound pickup. In addition, this characteristic is like wise outstanding in that this is the only type of microphone that responds uniformly to all audible frequencies over the entire 45° angle. This permits placing microphones in the footlights on approximately seven foot centers with the result that uniform pickup of all frequencies is accomplished across the front of the stage.

Another great advantage of the Velocity Microphone is its uniform operation independent of changes in climatic conditions such as atmospheric pressure, humidity, or temperature, any or all of which considerably affect other types of microphones.

The Velocity Microphones are designed for either suspension, program stand or footlight mounting.

B. Fifty type PA-32 Microphone Amplifier will be furnished. These amplifiers will be located on a specially constructed rack located in an amplifier room in the basement under the stage. The amplifier is carefully shielded to render it free from external interference and undesired pickup. The entire unit is enclosed in a cylindrical metal case particularly designed for wood rack mounting, and is mounted vertically with connections made through plugs at the top and bottom. Power supply to operate the unit is made available from the amplifier room on the projection room level.

Control Console

C. A type PS-78 Control Console is to be furnished for controlling the individual microphone amplifier outputs and mixing them properly for amplification. It is located in the control room, as shown in Figure 1. The console is of the mahogany desk type with metal top on which all the controls are located.

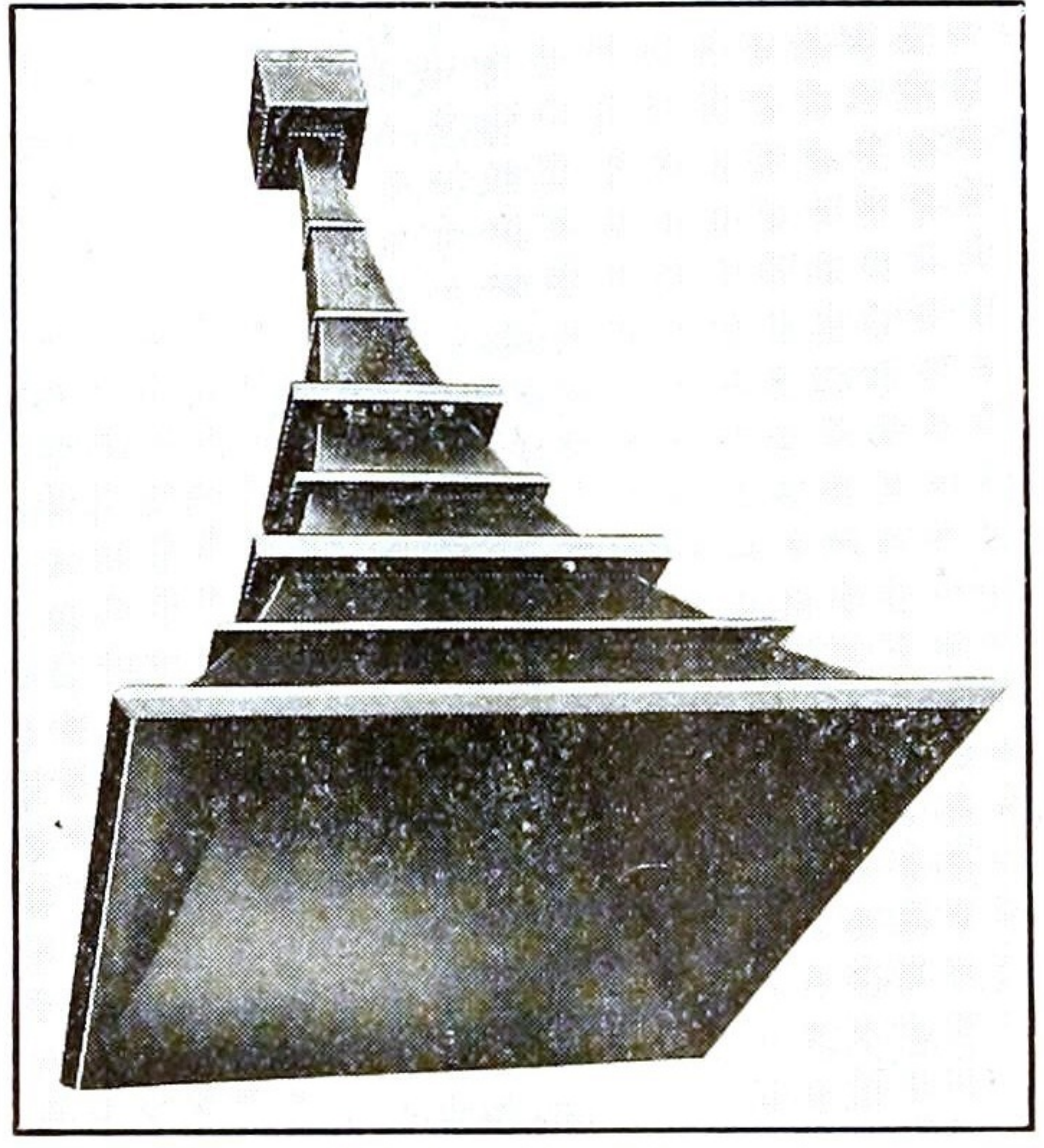
At the front right side of the control console is located an 80-jack panel at which point the outputs from the fifty microphone amplifiers terminate. The additional jacks not accounted for are for expansion. Directly in front of the jack panel are 38 cords and single plugs with weights and rollers divided into four groups, two of eleven each and two of eight each, each group with a distinctive color. The cords are arranged in four rows.

At the back right and left side of the control console are located four mixers—two eleven-position mixers and two eight-position mixers—each with its distinctive color on the mixer knob and wired to its respective cords mentioned above. On the console top a four-position mixer is located, one position for each of the above mentioned mixers, which controls the level of its respective group. By plugging the plugs into the jacks any combination of microphones, with a maximum of thirty-eight, in groups of eight or eleven may be selected and mixed in the four mixers. After this position the output of each of these four mixers is fed into the four-position mixer. A master mixer is located on the console top which controls the mixed output of the four-position mixer.

At the front left side of the console top a "booster amplifier" is located which compensates for the loss in the control console. The output from the master mixer is fed into this amplifier and the level is raised to such an extent that the output can be coupled to the main amplifier.

A Volume Indicator is mounted on the console top at the rear in a vertical position. An adjustment is supplied so that a predetermined reading on the meter may be made to represent any output level of the amplifier.

At the front left side of the console is located a jack panel for changing normal connections of the outputs of the eight position and the eleven position mixers into the four position mixers to prevent the failure of one unit of the four position mixer from interfering with the operation of the system. In case of emergency, it is also possible to circumvent the four position mixer and (or) the "booster amplifier" to feed directly into the main amplifier at a reduced output.



Type PL-35 Loudspeaker

The separate control units of the mixers can be removed for repair at a moment's notice, such removal not affecting the operation of the remaining units.

Amplifiers

D. The main amplifier equipment consists of two duplicate eighty watt amplifier channels, Type PB-84. These amplifiers are primarily arranged for operating in duplicate; that is, one at a time, the other being held in reserve for emergency use. However, provision has been made so that one channel may be used on the regular sound reinforcing system and the second channel used at the same time to operate the effect loudspeakers. These amplifiers, consist of units mounted on standard channel-iron racks and are located in the amplifier room as shown on Figure 1.

Each of the channels includes necessary terminal strips, main power line switch, a Type PB-23 voltage amplifier unit, two Type PB-45 Power Amplifier Units (40 watts each), and a Type PB-24 Power Amplifier unit (10 watts).

All amplifier units are complete in themselves in that they contain their own A.C. operated power supply apparatus.

The 10 watt power amplifier unit is used for the Deaf Headphone System The output impedance is such that a variable number of headphones may be installed. All headphones are connected across the output of the amplifier in series with an adjustable resistor of sufficiently high value that all headsets may be removed from their jacks without affecting the frequency characteristics of the system.

Miscellaneous Equipment Rack

E. The Type PB-50 Miscellaneous Equipment Rack which is located with the main amplifier includes an audio relay panel, two jack panels, a Type PB-51 tube testing panel, a Type PB-55 radio receiver, a Type PB-75 phonograph turntable, a Type PB-50 amplifier unit.

The audio relay panel includes the relays required to switch the deaf hearing system amplifier to either the sound reinforcing system or the main sound projection system, to switch either of the sound reinforcing system amplifier channels into the circuit and to connect the stage manager's call system to the sound reinforcing system when desired.

The two jack panels are used for "patching" or interconnecting. The input and output circuits of all amplifiers on the sound reinforcing system, rehearsal address system and stage manager's call system are brought out to these panels as well as the outputs of all special apparatus including radio receiver, phonograph turntable and the like. For normal operation no cords are required but for special interconnections or for use of special apparatus cords tying the desired circuits are used in these jack panels.

The Tube Testing Panel is designed to test all tubes and tube circuits employed in the amplifier and power racks.

The Radio Receiver is a nine tube superheterodyne radio receiver, providing excellent performance in all the features incorporated in modern radio broadcast receivers. Automatic volume control, push-pull pentode output stage, tone control, calibrated kilocycle dial and the inherent sensitivity, selectivity and tone quality of the superheterodyne circuit are some of the features of this receiver. This unit will work in conjunction with any of the power amplifier units in the system.

The Phonograph Turntable consists of a single turntable designed to operate at 78 revolutions per minute. A volume control is mounted on the base board adjoining the table. The whole unit is mounted on a panel which is hinged to the rack so that when it is not in use it is in a vertical position with the panel screwed to the rack channel. When in use it is lowered from the top and held rigid in front of the rack.

The amplifier unit included in this rack is used for monitoring purposes. This unit may be connected across the output of the power amplifier unit of either the sound reinforcing system, effect system (one channel of sound reinforcing system), stage manager's call system or the rehearsal address system and will operate the monitor loudspeakers on the Type PB-60 power control rack, in the amplifier room, in the spot cove, or at the chief electricians' position.

Power Control Rack

F. The Type PB-60 Power Control Rack is located adjacent to the control console in the control room, as shown in Figure 1. This rack includes a microphone power control panel, an amplifier power control panel a rehearsal microphone mixer an audio control panel a monitoring loudspeaker panel and a chief electrician's microphone control panel.

The microphone power control panel includes switches which through the use of relays turn on the power to all microphone transmitters and microphone amplifiers.

The amplifier power control panel includes switches which through the use of relays turn on the power to all the amplifiers used in the sound reinforcing system and rehearsal address system.

The rehearsal microphone mixer includes mixer units for controlling the output of each of the four microphones used on the system with a master mixer to control the group.

The Audio Control Panel includes two key switches one to select, through the use of relays, amplifier channels for this system and the other to connect, through the use of relays, the deaf hearing amplifier to either the sound reinforcing system or the main sound projection system. In addition, four remote volume control push button stations are included, controlling the volume on each of the amplifier channels of the sound reinforcing system, and of the rehearsal address system.

The Monitoring Loudspeaker Panel includes a panel mounted electrodynamic loudspeaker unit with volume control.

The chief electricians' microphone control panel consists of a control unit to equalize the output of the carbon microphone used by the chief electrician on the rehearsal address system to the three velocity microphones used on the same system.

Power Supply Racks

G. The Type PB-76 Loudspeaker Control Rack is located also adjacent to the control console in the control room as shown in Figure 1. The rack includes two sound reinforcing loudspeaker control panels and two rehearsal loudspeaker control panels.

H. The Type PB-56 Power Supply rack which is located in the motor generator set room, as shown on Figure 1, includes an A.C. relay panel, two D.C. relay panels, and two plate and bias supply units.

The A.C. relay panel includes a number of relays to connect the A.C. supply to the rectifier tubes. The two D.C. relay panels include a number of relays to connect the power supply to the microphones of both the sound reinforcing system and the rehearsal address system.

The two plate and bias supply units are connected in duplicate, one being used regularly and the other as emergency, and are used to supply plate and bias power to the microphone amplifiers and the "booster amplifier." The unit is designed to operate from a 205-220 volt, three phase, 60 cycle A.C. supply. It is essentially a three phase—six phase rectifier. This type of unit by virtue of its fundamental principle of operation reduces the percentage of A.C. ripple voltage in the D.C. output voltage of the rectifier tubes. This is a distinct advantage over the common one and two phase rectifiers in that less filtering is required at 360 cycles to reduce the percentage of ripple voltage to any predetermined level than at 120 cycls. This reduction in required filtering improves the regulation of the rectifier in that the series resistance factor of filter inductances is reduced to a minimum. The regulation of the rectifier is further improved by the use of the mercury vapor (Radiotron UX-866) rectifier because the voltage drop in this tube is practically constant for any load within the tube rating. These factors are very important because of the fact that this rectifier supplies plate power to several microphone amplifiers.

J. The Type PB-79 Power Supply rack is located adjacent to the PB-36 power supply rack and includes an A.C. relay panel, two Type PK-15 loudspeaker field supply panels and two Type PK-20 loudspeaker field supply panels.

The A.C. Relay Panel includes a number of relays to connect the power to the amplifier of the sound reinforcing system, effect system and rehearsal address system.

The two Type PK-15 loudspeaker field supply panels are used to supply power to the loudspeaker fields of the radio and monitoring system. Each panel delivers 0.5 amperes at 100 volts.

The two Type PK-20 loudspeaker field supply panels are connected in duplilcate, one being used regularly and the other for emergency, and are used to supply power to the fields of the sound reinforcing system and rehearsal address system loudspeakers. Each panel delivers 4.0 amperes at 100 volts.

Battery Supply

K. The battery power supply equipment is all located in the battery room as shown in Figure 1. This equipment includes four sets of glass jar storage batteries together with charging equipment.

A duplicate set of storage battery cells with a capacity of 1040 ampere hours is furnished to supply filament current to all microphone amplifiers and field supply to all velocity microphone transmitters of the sound reinforcing system and rehearsal address system.

A duplicate set of storage battery cells with a capacity of 186 ampere hours is furnished to supply excitation to all relays used with these systems.

The cells are all mounted in racks against the wall.

A battery charging motor-generator set, together with control panel, starter, and necessary switches and conduit boxes is also furnished. The sets of storage battery cells are so connected that one set of each type are in use when the duplicate sets are being charged.

Loudspeakers

L. Six loudspeakers are furnished for use on the sound reinforcing system in the auditorium, four Model 4 PL35A1 loudspeakers and two Model PL35B1 loudspeakers. These loudspeakers consist of a directional baffle of the exponential type coupled to a six-inch cone driver of rugged construction. This type of loudspeaker combines the advantage of a flat frequency characteristic with high efficiency, uniformity of response over the entire angle of distribution and high power handling capacity. Figure 2 shows a view of one of these loudspeakers.

The four Model 4 PL35A1 loudspeakers employing 60-inch directional baffles are to be mounted behind a grill above the proscenium arch.

The two Model 4 PL35B1 loudspeakers employing 37-inch directional baffles are to be mounted in the wall, one on each side of the proscenium arch.

M. For effect purposes two Type PL-64 loudspeakers employing 17 directional baffles will be furnished for mounting at the rear of the stage over the rear stage projection room. These speakers may be connected to the second amplifier channel of the sound reinforcing system for simultaneous or separate operation when back-stage sound effects are desired. Each directional baffle employs four of the six-inch cone units.

N. For monitoring purposes three Model AF6179 loudspeakers will be furnished, one to be located in the spot cove, one at the chief electrician's position, and one in the amplifier room. These loudspeakers consist of a standard magnetic speaker mechanism mounted in the rear of a specially designed wood plaque faced with three-ply veneer and the center of matched oriental walnut.

The over-all frequency characteristic of the sound reinforcing system is such as to give faithful uniform reproduction over the entire range of 50 to 10,0000 cycles.

Main Sound Projection System

This system consists of a duplicate channel eighty watt A.C. operated sound reproducing system employing four soundhead attachments. This equipment is similar in every detail to the "standard" series of RCA photophone sound reproducing equipment. The entire projection room equipment is finished in a specially selected green to match the balance of the projection room equipment.

A. Four Type PS-20 Simplex soundhead attachments are to be furnished with this system for mounting in the projection rom as shown in Figure 1. These attachments are to be mounted on Chicago cinema bases with super Simplex mechanisms. The attachment is the same as supplied with "standard" series RCA Photophone equipment except that three phase A.C. motors are employed.

(*Continued on page* 29)

IN ROCKEFELLER CENTER

(*Continued from page* 13)

Amplifiers

B. A duplicate channel eighty-watt main amplifier, Type PA-88 and Type PA-87 is to be furnished with this system. The voltage and power amplifier units are the same as those used on the sound reinforcing system (No. 1). These racks are located in the rear wall of the projection room, as shown on Figure 1. These racks are particularly adapted for flush mounting in the wall because all servicing is done from the front.

The Type PA-88 Amplifier includes necessary terminal strips, main line power switch, a Type PB-23 voltage amplifier unit, two Type PB-45 power amplifier units (40 watts each), a jack panel, a Type PB-63 dual channel switching panel, a type PB-64 projector changeover panel and a Type PK-21 loudspeaker field supply panel. The jack panel is to be used for "patching." By this means the main sound projection system may be interconnected with any of the other systems. The rear stage projection system is terminated at this panel and may be connected to the main sound projection system by the use of patching cords. For normal operation, no cords are required. The dual channel switching panel includes a switch with a knob mounted on it for switching from one amplifier channel to the other. The projector changeover panel includes a number of relays and pilot lamps to connect the output of any of the four projectors to the input of the correct amplifier channel. The loudspeaker field supply panel is of sufficient size to produce 0.8 amperes at 100 volts.

The Type PA-87 amplifier includes necessary terminal strips, main line power switch, a Type PB-23 voltage amplifier unit, two type PB-45 power amplifier panels (40 watts each), a Type PL-21 loudspeaker field supply panel, and a Type BB-51 tube testing panel. The tube testing panel is the same in design and purpose as that supplied with the sound reinforcing system.

C. Located alongside the duplicate amplifier channels a Type PB-65 power supply rack is to be located. This rack includes four Type PK-17 exciter lamp panels and a Type PA-80 monitoring amplifier unit. Each panel delivers 5.0 amperes at 10.0 volts. One exciter lamp panel is supplied for each soundhead attachment. The monitoring amplifier unit is similar to the one described in the sound reinforcing system and operates the monitor loudspeaker in the projection room.

D. Four fader and volume control stations are to be furnished for wall mounting, one in front of each projector, for fading the amplifier input to the proper soundhead attachment and for controlling the volume of sound emitted by the loudspeaker. A remote volume control indicator consisting of twenty indicator lamps which indicate the amplifier volume control setting is to be furnished for wall mounting in the projection room. Five remote volume key control stations for mounting at various points in the auditorium are to be furnished.

E. The stage loudspeaker equipment to be used with this system consists of three Modell 4PL35C1 loudspeakers (10 foot baffle) and three Model 4PL35A1 loudspeakers (60 inch baffles). These loudspeakers are similar to those supplied with the sound reinforcing system and illustrated by Figure 8. A Model 4PL35B1 loudspeaker (37-inch baffle) with metal frame and mesh covering is to be mounted in the rear wall of the projection room for monitoring purposes.

This sound system comprises the latest and most modern sound reproducing equipment available for theatres. It is all A.C. operated, simple in design, compact for easy installation, easy to operate, and requires a low maintenance cost. The over-all characteristic of the system is such as to provide for faithful reproduction of all the audible frequencies from 50 to 10,000 cycles. A curve indicating this response is shown in Figure 13.

Rear Stage Projection System

This system is to be used for the projection of sound motion pictures from the rear of the stage to be used as background and for effects in conjunction with the stage presentations. It is all located in the rear stage projection room.

A. Two Type PS-20 Simplex soundhead attachments for mounting on Chicago cinema bases with super simplex mechanism are to be furnished with this system. These attachments are the same as those supplied with the main sound projection system.

B. A Type PB-65 amplifier unit as illustrated in Figure 14 consists of necessary terminal strips, a main line power switch, a Type PB-23 Voltage amplifier unit, a Type PB-74 projector changeover panel and a Type PK-17 exciter lamp panel. This unit is designed to be connected to the input of the main amplifier of the main sound projection system. The units are similar to those furnished with the main sound projection system, except that the projector changeover panel provides for only two projectors.

C. A Type PB-36 film phonograph will be furnished with this system. This unit is to be used for reproduction of a film record type of recording either alone or in conjunction with a picture on a separate film.

D. A Type PA-79 phototube amplifier is to be furnished for operation with the film phonograph to feed directly into the input of the main amplifier of the main sound projection system. The amplifier is mounted on the table of the film phonograph.

E. Two projector changeover switches are to be furnished, one mounted in front of each projector for operating the projector changeover panel.

F. A Model AF6179 loudspeaker employing a magnetic speaker unit on a flat baffle is used for monitoring purposes.

Preview Projection System

Two preview rooms located on the studio floor are to be equipped with sound projection systems. These systems are similar in general design to those furnished with the main sound projection system except that they have a smaller power output.

The Soundhead attachments are exactly similar to those supplied with the main and rear stage projection systems.

The amplifier equipment is likewise similar, consisting of a Type PB-23 voltage amplifier unit and a Type PB-24 (10-watt) power amplifier unit, together with a Type PK-17 exciter lamp supply panel and a Type PK-15 loudspeaker field supply panel. A remote volume control equipment is also included with this amplifier.

A Standard Type PL-64 monitering loudspeaker and a Model 4 PL35A1 (37-inch baffle) stage loudspeaker is supplied. A mounting frame for the stage loudspeaker has been included.

A desk mounting volume control, and fader and volume control switches for installation at each propjector are supplied.

Sound systems in Rockefeller Center, New York

By JAMES FRANK, JR.*

THE city in a city now rapidly nearing completion in New York and to be known as Rockefeller Center is to include two theatres, the larger to be known as the "International Music Hall" with a seating capacity of 6,300 seats, the smaller to be called the "RKO Photoplay Theatre" and having a seating capacity of 3,000 seats.

The installation for the "International Music Hall" is the larger and covers a wider scope. It has a total undistorted output of 510 watts.

The RCA Victor sound systems to be installed in the larger theatre are divided into eight units, as follows:

1. Sound reinforcing system.
2. Rehearsal address system.
3. Stage manager's call system.
4. Main sound projection system.
5. Rear stage sound projection system.
6. Deaf headphone system.
7. Preview sound projection systems.
8. Radio and monitoring system.

The installation of these systems is to be so arranged that through physical location and electrical connection certain of the equipments may be interconnected. Fig. 1 shows the equipment layout on the projection room level. From the diagram the various amplifiers and sound reproducers may be easily located.

It is important to note that the amplifiers and loudspeakers used on the various systems are essentially alike, although various assemblies of apparatus are employed.

Sound Reinforcing System

The purpose of this system is to reinforce the stage presentations and orchestra music to suitable levels in order that the desired aesthetic effects and clear intelligibility may be obtained at all points in the auditorium. This system consists essentially of a number of microphones, amplifier equipment, and loudspeakers, together with necessary control apparatus. The microphone transmitters located around the stage and orchestra pit pick up the voices or music, change the sound waves to electrical waves, which are fed into the microphone amplifiers. After the level has been raised by these units the electrical waves are fed into the mixers in the control console where they are properly mixed and then fed into a "booster amplifier." At this point the level is sufficiently raised to feed into the main amplifiers. From the main amplifier the electrical waves, now at any desired level, are fed into the auditorium loudspeakers where they are converted into sound waves again which are directed to all points in the auditorium.

A. Fifty type PB-31 velocity microphones of the type used for sound recording will be furnished, mounted on swivel bases in order that they may be "aimed" in any desired direction. These microphones will be located as follows:

Eight in traps in the floor of the orchestra elevator.

Eight on program stands on band wagon.

Eight suspended from light bridges.

Eleven in footlights approximately on seven-foot centers.

Nine on stage connected to traps on the stage floor.

Six (3 on each side) on choral stairs.

The velocity microphone contains a thin metallic ribbon suspended between the poles of a permanent magnet in place of a diaphragm. Sound waves reaching the ribbon vibrate it within the magnetic field set up by the magnet.

The microphone responds faithfully to all sound vibration over the range of audible frequencies from 30 to above 10,000 cycles.

The most important characteristic of the velocity microphone is its directional property. Since the ribbon is suspended in free space, sound waves approaching the microphone from a direction on the same plane as the ribbon have no effect upon it, but sound waves from either direction along an axis perpendicular to the plane of the ribbon have a maximum effect. For equal distances from the transmitter, sound originating 70° or 80° off the axis perpendicular to the ribbon will have practically no effect, whereas at 45° off this perpendicular the sensitivity is approximately 70% of the maximum. This characteristic is of great value in the solution of some of the difficulties usually encountered in reverberant locations by the reduction of the effect of undesired sound reflections, and in the increased possibilities of obtaining better balance and selectivity in sound pickup. In addition, this characteristic is likewise outstanding in that this is the only type of microphone that responds uniformly to all audible frequencies over the entire 45° angle. This permits placing microphones in the footlights on approximately seven-foot centers with the result that uniform pickup of all frequencies is accomplished across the front of the stage.

B. Fifty type PA-82 microphone amplifiers will be furnished. These amplifiers will be located on a specially constructed rack located in an amplifier room in the basement under the stage. The amplifier is carefully shielded to render it free from external interference and undesired pickup. The entire unit is enclosed in a cylindrical metal case particularly designed for wood rack mounting, and is mounted vertically with connections made through plugs at the top and bottom. Power supply to operate the unit is made available from the amplifier room on the projection room level.

C. A type PB-78 control console as illustrated in Fig. 2 is furnished for controlling the individual microphone amplifier outputs and mixing them properly for amplification. It is located in the control room as shown in Fig. 1. The console is of the mahogany desk type with metal top on which all the controls are located.

At the front right side of the control console is located an 80-jack panel at

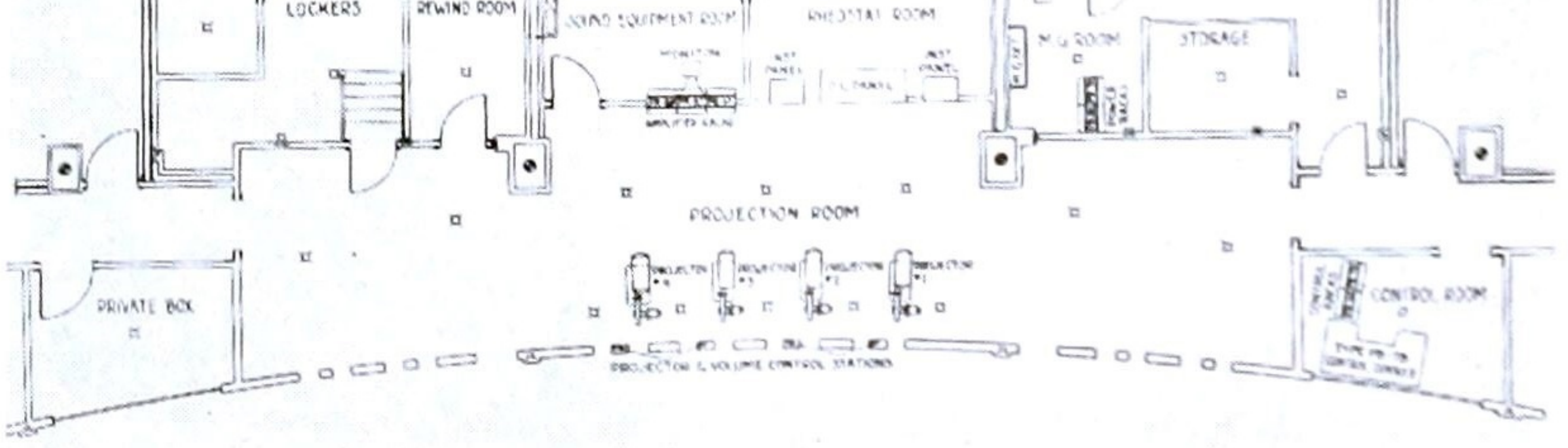


Fig. 1. Apparatus layout on projection room level

which point the outputs from the fifty microphone amplifiers terminate. The additional jacks are for expansion. Directly in front of the jack panel are 38 cords and single plugs with weights and rollers divided into four groups, two of eleven each and two of eight each, each group with a distinctive color. The cords are arranged in four rows.

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*Photophone Division, RCA-Victor Company.

At the back right and left side of the control console are located four mixers, two eleven-position mixers and two eight-position mixers, each with its distinctive color on the mixer knob and wired to its respective cords mentioned. On the console top a four-position mixer is located, one position for each of the mentioned mixers, which controls the level of its respective group. By plugging into the jacks any combination of microphone, with a maximum of thirty-eight, in groups of eight or eleven may be selected and mixed in the four mixers. After this position the output of each of these four mixers is fed into the four-position mixer. A master mixer is located on the console top which controls the mixed output of the four-position mixer.

At the front left side of the console top a "booster amplifier" is located which compensates for the loss in the control console. The output from the master mixer is fed into this amplifier and the level is raised to such an extent that the output can be coupled to the main amplifier.

A volume indicator is mounted on the console top at the rear in a vertical position. An adjustment is supplied so that a predetermined reading on the meter may be made to represent any output level of the amplifier.

At the front left side of the console is located a jack panel for changing normal connections of the outputs of the eight position and the eleven position mixers into the four position mixers to prevent the failure of one unit of the four position mixer from interfering with the operation of the system. In case of emergency it is also possible to circumvent the four position mixer and/or the "booster amplifier" to feed directly into the main amplifier at a reduced output.

The separate control units of the mixers can be removed for repair at a moment's notice, such removal not affecting the operation of the remaining units.

D. The main amplifier equipment consists of two duplicate eighty watt amplifier channels, Type PB-84. These amplifiers are primarily arranged for operating in duplicate; that is, one at a time, the other being held in reserve for emergency use. However, provision has been made so that one channel may be used on the regular sound reinforcing system and the second channel used at the same time to operate the effect loudspeakers. These amplifiers consist of units mounted on standard channel-iron racks and are located in the amplifier room as shown in Fig. 1.

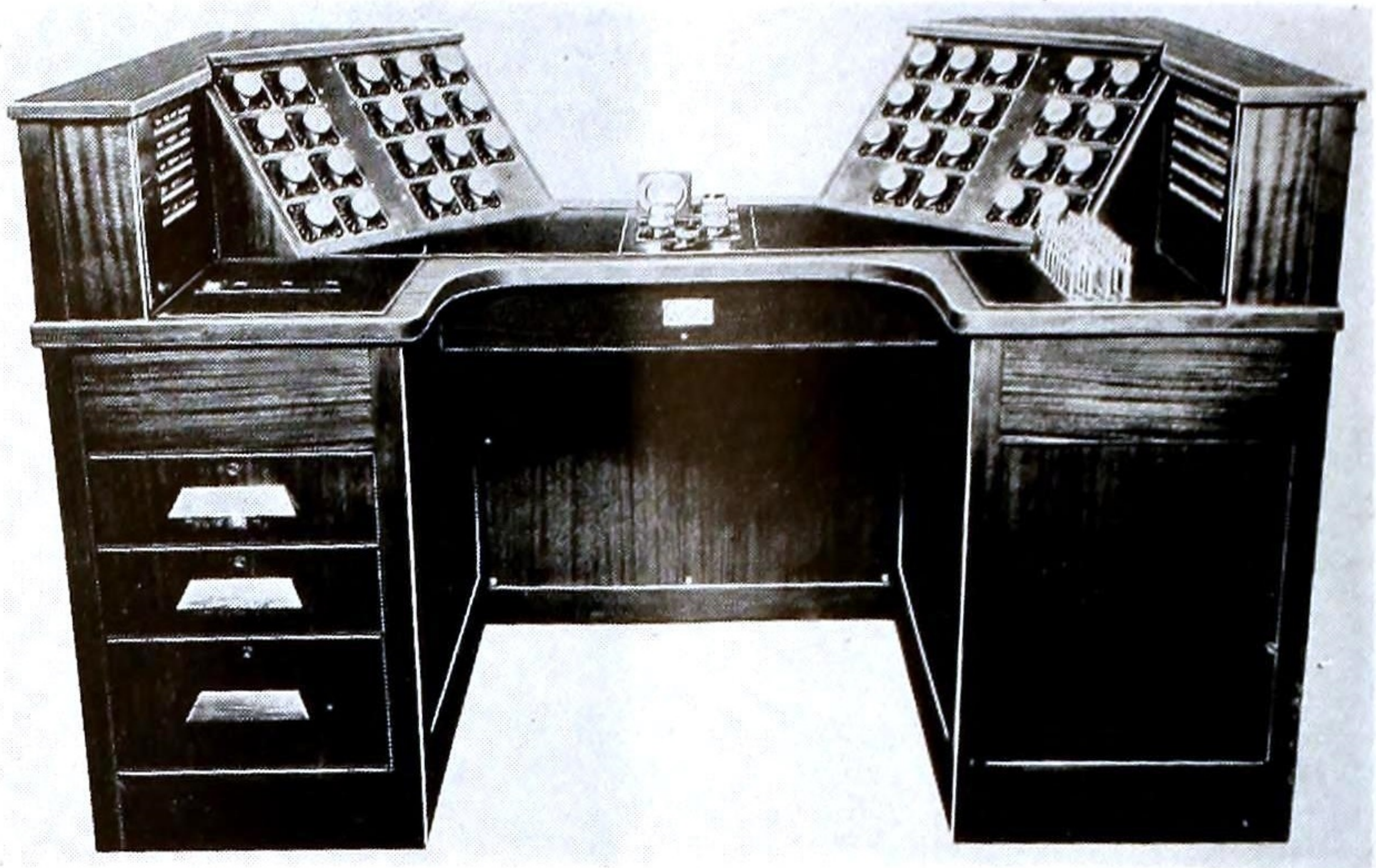

Fig. 2. Control Console (PB-78)

Each of the channels include necessary terminal strips, main power line switch, a Type PB-23 voltage amplifier unit, two Type PB-45, power amplifier units (40 watts each) and a Type PB-24 power amplifier unit (10 watts).

All amplifier units are complete in themselves in that they contain their own a-c. operated power supply apparatus.

Headphone System

The 10-watt power amplifier unit is used for the deaf headphone system. The output impedance is such that a variable number of headphones may be installed. All headphones are connected across the output of the amplifier in series with an adjustable resistor of sufficiently high value that all headsets may be removed from their jacks without affecting the frequency characteristics of the system.

E. The Type PB-50 miscellaneous equipment rack which is located with the main amplifier includes an audio relay panel, two jack panels, a Type PB-51 tube testing panel, a Type PB-55 radio receiver, a Type PB-75 photograph turntable, a Type PA-80 amplifier unit.

The audio relay panel includes the relays required to switch the deaf hearing system amplifier to either the sound reinforcing system or the main sound projection system, to switch either of the sound reinforcing system amplifier channels into the circuit, and to connect the stage manager's call system to the sound reinforcing system when desired.

The two jack panels are used for "patching" or "interconnecting." The input and output circuits of all amplifiers on the sound reinforcing system, rehearsal address system and stage manager's call system are brought out to these panels as well as the outputs of all special apparatus including radio receiver, phonograph turntable, and the like. For normal operation no cords are required, but for special interconnections or for use of special apparatus cords tying the desired circuits are used in these jack panels.

The radio receiver is a nine-tube superheterodyne providing excellent performance in all the features incorporated in modern radio broadcast receivers. Automatic volume control, push-pull pentode output stage, tone control, calibrated kilocycle dial and the inherent sensitivity, selectivity, and tone quality of the superheterodyne circuit are some of the features of this receiver. This unit will work in conjunction with any of the power amplifier units in the system.

The phonograph turntable consists of a single turntable designed to operate at 78 revolutions per minute. A volume control is mounted on the base board adjoining the table. The whole unit is mounted on a panel which is hinged to the rack so that when it is not in use it is in a vertical position with the panel screwed to the rack channel. When in use it is lowered from the top and held rigid in front of the rack.

The amplifier unit included in this rack is used for monitoring purposes. This unit may be connected across the output of the power amplifier unit of either the sound reinforcing system, effect system (one channel of sound reinforcing system), stage manager's call system or the rehearsal address system and will operate the monitor loudspeaker on the Type PB-60 power control rack, in the amplifier room, in the spot cove, or at the chief electrician's position.

F. The Type PB-60 power control rack is located adjacent to the control console in the control room as shown in Fig. 1. This rack includes a microphone power control panel, an amplifier power control panel, a rehearsal microphone mixer, an audio control panel, a monitoring loudspeaker panel, and a chief electrician's microphone control panel.

The microphone power control panel

included switches which through the use of relays turn on the power to all microphone transmitters and microphone amplifiers.

The amplifier power control panel includes switches which through the use of relays turn on the power to all the amplifiers used in the sound reinforcing system and rehearsal address system.

The rehearsal microphone mixer includes mixer units for controlling the output of each of the four microphones used on the system with a master mixer to control the group.

Audio Control Panel

The audio control panel includes two key switches, one to select, through the use of relays, amplifier channels for this system and the other to connect, through the use of relays, the deaf hearing system amplifier to either the sound reinforcing system or the main sound projection system. In addition, four remote volume control push button stations are included, controlling the volume on each of the amplifier channels of the sound reinforcing system, and of the rehearsal address system.

The monitoring loudspeaker panel includes a panel mounted electro-dynamic loudspeaker unit with volume control.

The chief electrician's microphone control panel consists of a control unit to equalize the output of the carbon microphone used by the chief electrician on the rehearsal address system to the three velocity microphones used on the same system.

G. The Type PB-76 loudspeaker control rack is located also adjacent to the control console in the control room as shown in Fig. 1.

H. The Type PB-56 power supply rack which is located in the motor generator set room as shown in Fig. 1 includes an a-c. relay panel, two d-c. relay panels, and two plate and bias supply units.

The a-c. relay panel includes a number of relays to connect the a-c. supply to the rectifier tubes. The two d-c. relay panels include a number of relays to connect the power supply to the microphones of both the sound reinforcing system and the rehearsal address system.

The two plate and bias supply units are connected in duplicate, one being used regularly and the other as emergency, and are used to supply plate and bias power to the microphone amplifiers and the "booster amplifier." The unit is designed to operate from a 205-220 volt, three phase, 60 cycle a-c. supply. It is essentially a three phase-six phase rectifier. This type of unit by virtue of its fundamental principle of operation reduces the percentage of a-c. ripple voltage in the d-c. output voltage of the rectifier tubes. This is a distinct advantage over the common one and two phase rectifiers in that less filtering is required at 360 cycles to reduce the percentage of ripple voltage to any predetermined level than at 120 cycles. This reduction in required filtering improves the regulation of the rectifier in that the series resistance factor of filter inductances is reduced to a minimum. The regulation of the rectifier is further improved by the use of the mercury vapor (Radiotron UX-866) rectifier because the voltage drop in this tube is practically constant for any load within the tube rating. These factors are very important because of the fact that this rectifier supplies plate power to several microphone amplifiers.

J. The Type PB-79 power supply rack is located adjacent to the PB-36 power supply rack and includes an a-c. relay panel, two Type PK-15 loudspeaker field supply panels and two Type PK-20 loudspeaker field supply panels.

The a-c. relay panel includes a number of relays to connect the power to the amplifier of the sound reinforcing system, effect system and rehearsal address system.

The two Type PK-15 loudspeaker field supply panels are used to supply power to the loudspeaker fields of the radio and monitoring system No. 8. Each panel delivers 0.5 ampere at 100 volts.

The two Type PK-20 loudspeaker field supply panels are connected in duplicate, one being used regularly and the other for emergency, and are used to supply power to the fields of the sound reinforcing system and rehearsal address system loudspeakers. Each panel delivers 4.0 amperes at 100 volts.

K. The battery power supply equipment is all located in the battery room as shown in Fig. 1. This equipment includes four sets of glass jar storage batteries together with charging equipment.

A duplicate set of storage battery cells with a capacity of 1,040 ampere hours is furnished to supply filament current to all microphone amplifiers and field supply to all velocity microphone transmitters of the sound reinforcing system and rehearsal address system.

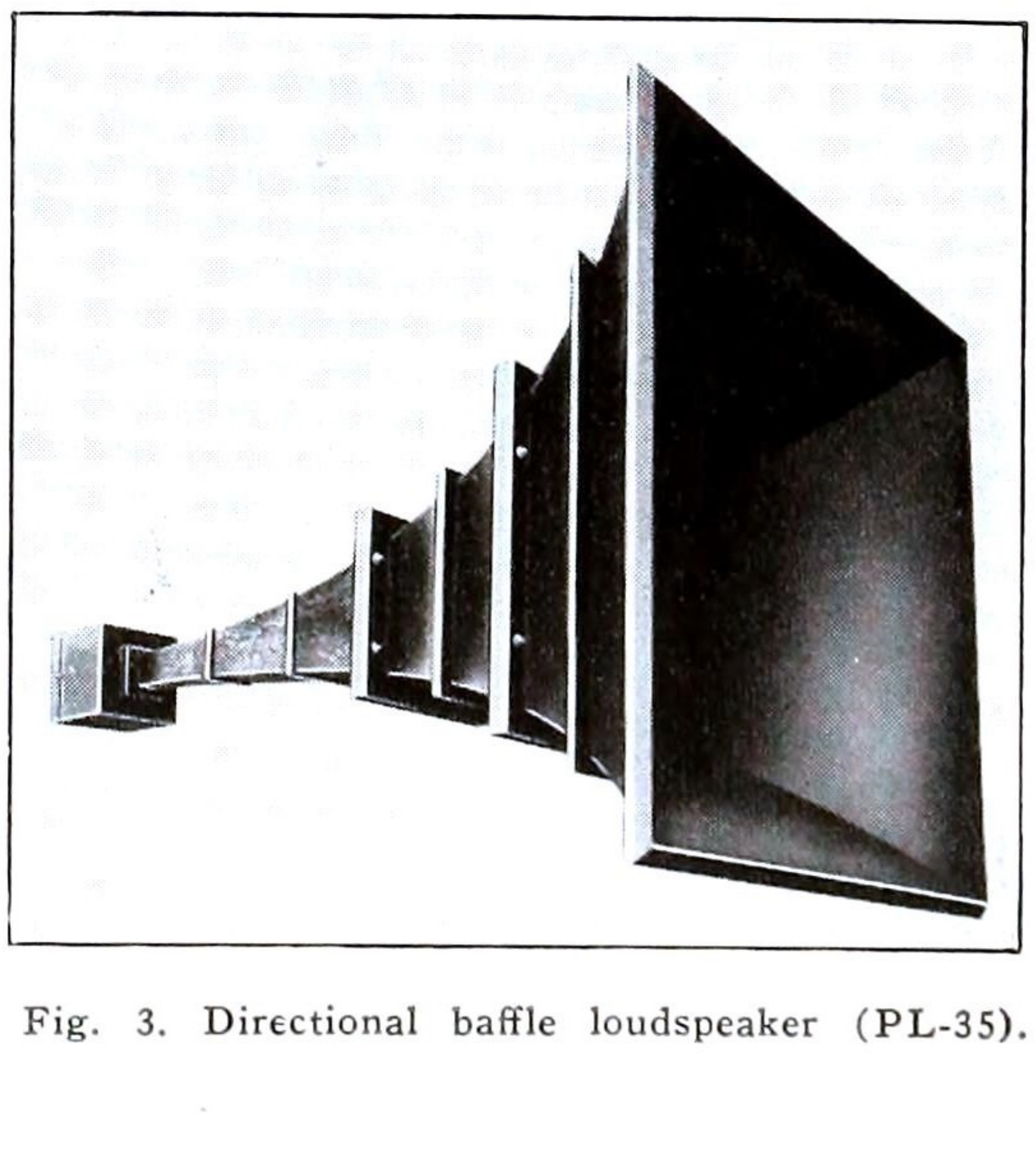

Fig. 3. Directional baffle loudspeaker (PL-35).

Relay Excitation

A duplicate set of storage battery cells with a capacity of 186 ampere hours is furnished to supply excitation to all relays used with these systems. The cells are all mounted in racks against the wall.

A battery charging motor-generator set together with control panel, starter, and necessary switches, and conduit boxes is also furnished. The sets of storage battery cells are so connected that one set of each type is in use when the duplicate sets are being charged.

L. Six loudspeakers are furnished for use on the sound reinforcing system in the auditorium, four Model 4 PL35A1 loudspeakers and two Model 4 PL35B1 loudspeakers. These loudspeakers consist of a directional baffle of the exponential type coupled to a six-inch cone driver of rugged construction. This type of loudspeaker combines the advantage of a flat frequency characteristic with high efficiency, uniformity of response over the entire angle of distribution and high power handling capacity. Fig. 3 shows a view of one of these loudspeakers.

The four Model 4 PL35A1 loudspeakers employing 60-inch directional baffles are to be mounted behind a grill above the proscenium arch.

The two Model 4 PL35B1 loudspeakers employing 37-inch directional baffles are to be mounted in the wall, one on each side of the proscenium arch.

M. For effect purposes two Type PL-64 loudspeakers employing 17-foot directional baffles will be furnished for mounting at the rear of the stage over the rear stage projection room. These speakers may be connected to the second amplifier channel of the sound reinforcing system for simultaneous or separate operation when back-stage sound effects are desired. Each directional baffle employs four of the six-inch cone units.

N. For monitoring purposes three Model AF6179 loudspeakers will be furnished, one to be located in the spot cove, one at the chief electrician's position, and one in the amplifier room. These loudspeakers consist of a standard magnetic speaker mechanism mounted in the rear of a specially designed wood plaque faced with three-ply veneer and the center of matched oriental walnut.

The overall frequency characteristic of the sound reinforcing system is such as to give faithful uniform reproduction over the entire range of 50 to 10,000 cycles.

(To be concluded)

Sound systems in Rockefeller Center, New York

By James Frank, Jr.*

(Concluded from November Issue)

Rehearsal Address System

THIS system is to be used in connection with the execution of rehearsals of stage and orchestra presentations. It consists essentially of microphones located at definite positions feeding through amplifiers to a number of loudspeakers located to cover the stage, auditorium and various booths.

Three velocity microphone transmitters will be furnished mounted on stands, two of telescope stand type, and one of the desk stand type. One of these will be located on a desk which will be placed in the twelfth row of the orchestra floor during rehearsals. Another will be located in the director's private box located at the rear of the auditorium. The third is to be located in the control room.

In addition, a carbon microphone announcing station including necessary switches and pilot lamps is to be located at the chief electrician's position.

Three velocity microphone amplifiers will be furnished, one for each of the above mentioned velocity microphone transmitters. The amplifier for the transmitter located at the twelfth row of the orchestra floor will be located in the amplifier room in the basement under the stage where the amplifiers for the sound reinforcing system are located. The amplifier for the transmitter located in the director's private box is to be located on the wall of the adjacent "spot booth" while the amplifier for the transmitter in the control room is to be located on the wall of that room.

The main amplifier used for this system is similar to one of the amplifier channels used on the sound reinforcing system. The equipment includes necessary terminal strips, main power line switch, a voltage amplifier unit, and two power amplifier units (40 watts). The rack is located adjacent to the main amplifiers of the sound reinforcing system in the amplifier room.

A large number of loudspeakers are used with this system to cover the auditorium, entire stage including light towers, light control stations, and various spot and equipment booths. This equipment includes twenty-five loudspeakers employing 37-inch directional baffles, seven loudspeakers employing magnetic units on flat wood baffles.

Through the use of these loudspeakers the director or anyone else at a microphone location may communicate with anyone in the theatre concerned with the rehearsal. This system may be used during regular performances operating certain of the loudspeakers at low level.

Main Sound Projection System

This system consists of a duplicate channel 80 watt a-c. operated system employing four soundhead attachments. This equipment is similar in every detail to the "standard" series of RCA Photophone sound reproducing equipment. The entire projection room equipment is finished in a specially selected green to match the balance of the projection room equipment.

Four Simplex soundhead attachments are furnished with this system for mounting in the projection room. These attachments are to be mounted on Chicago cinema bases with Super-Simplex mechanisms. The soundhead attachment is illustrated in Fig. 4. The attachment is the same as supplied with "standard" series RCA equipment except that three phase a-c. motors are employed.

A duplicate channel 80 watt main amplifier is to be furnished with this system. The voltage and power amplifier units are the same as those used on the sound reinforcing system. These racks are located in the rear wall of the projection room. These racks are particularly adapted for flush mounting in the wall because all servicing is done from the front.

The Type PA-88 amplifier includes necessary terminal strips, main line power switch, a voltage amplifier unit, two power amplifier units (40 watts each), a jack panel, a dual channel switching panel, a projector changeover panel and a loudspeaker field supply panel. The jack panel is to be used for "patching. By this means the main sound projection system may be interconnected with any of the other systems. The rear stage projection system is terminated at this panel and may be connected to the main sound projection system by the use of patching cords. For normal operation, no cords are required. The dual channel switching panel includes a switch with a knob mounted on it for switching from one amplifier channel to the other. The projector changeover panel includes a number of relays and pilot lamps to connect the output of any of the four projectors to the input of the correct amplifier channel. The loudspeaker field supply panel is of sufficient size to produce 0.8 ampere at 100 volts.

The amplifier includes necessary terminal strips, main line power switch, a voltage amplifier unit, two power amplifier panels (40 watts each), a loudspeaker field supply panel, and a tube testing panel.

Located alongside the duplicate amplifier channels a power supply rack is to be located. This rack includes four exciter lamp panels and a monitoring amplifier unit. Each panel delivers 5.0 amperes at 10.0 volts. One exciter lamp panel is supplied for each soundhead attachment.

Four fader and volume control stations are to be furnished for wall mounting, one in front of each projector, for fading the amplifier input to the proper sound head attachment and for controlling the volume of sound emitted by the loudspeakers. A remote volume control indicator consisting of twenty indicator lamps which indicate the amplifier volume control setting is to be furnished for wall mounting in the projection room. Five remote volume key control stations for mounting at various points in the auditorium are to be furnished.

The stage loudspeaker equipment to

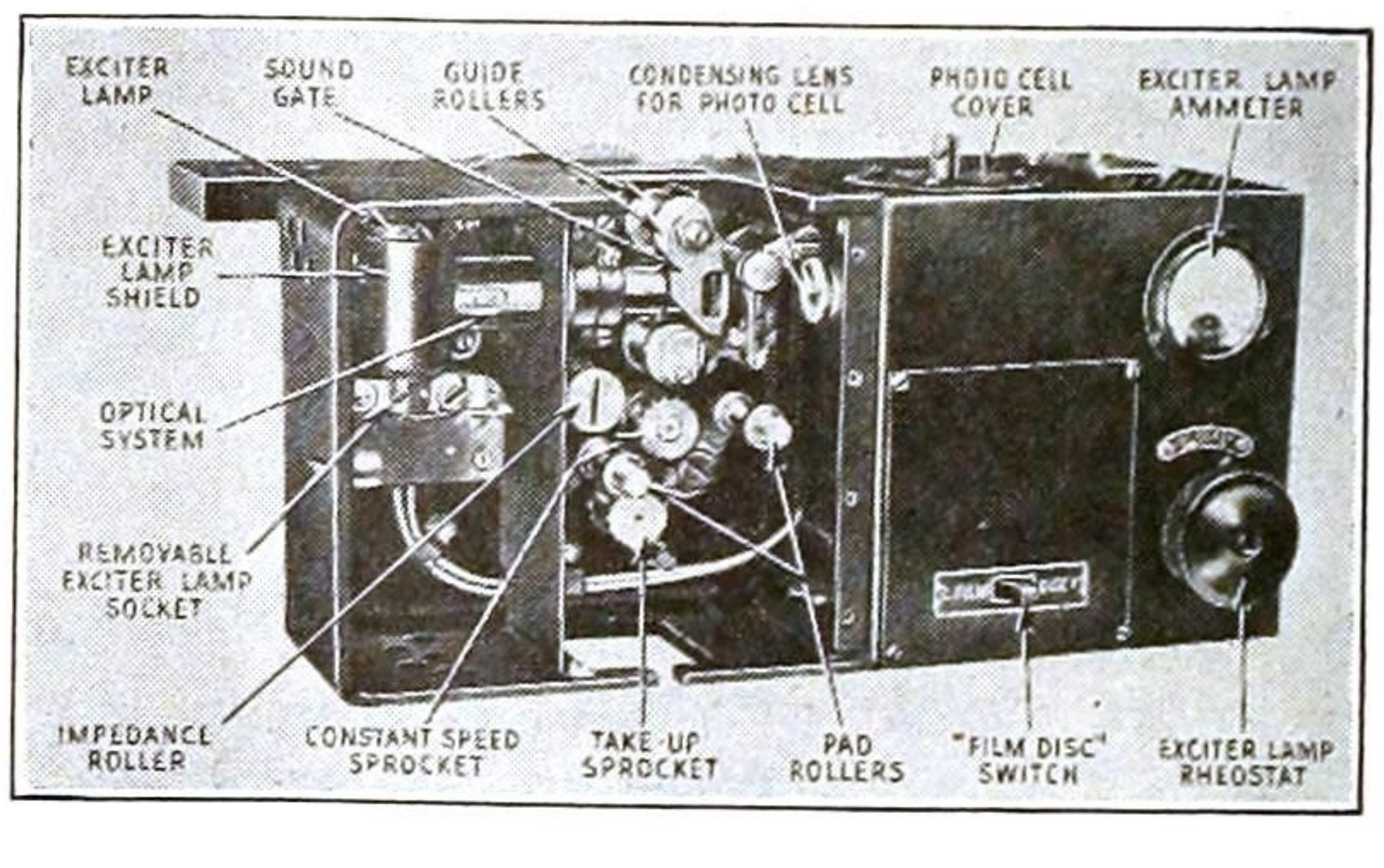

Fig. 4. Simplex sound head attachment.

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*Photophone Division, RCA-Victor Company.

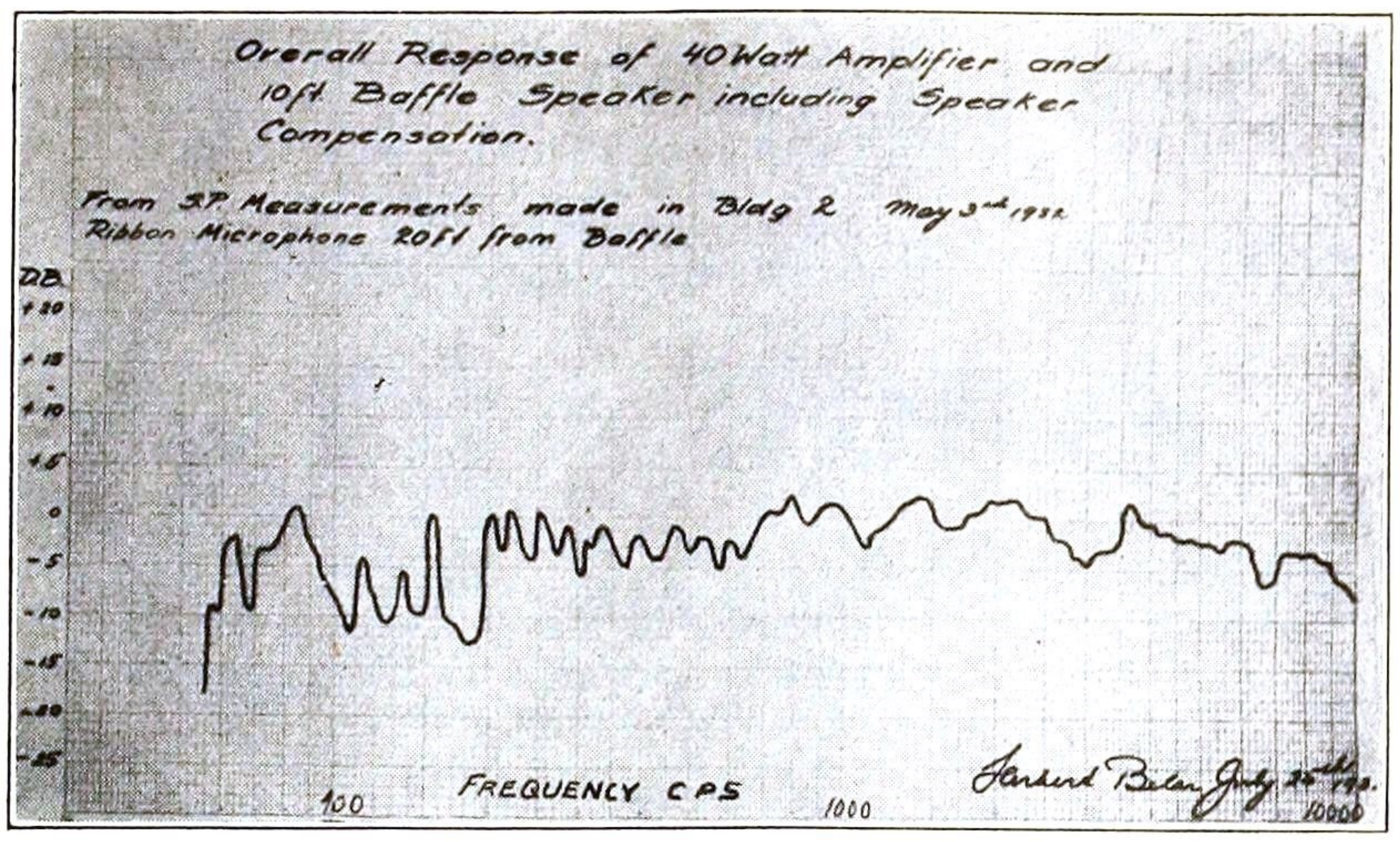

Fig. 5. Overall frequency response curve of main sound projection system.

be used with this system consists of three loudspeakers (10-inch baffles) and three loudspeakers (60-inch baffles). A loudspeaker (37-inch baffle) with metal frame and mesh covering is to be mounted in the rear wall of the projection room for monitoring purposes.

This sound system comprises the latest and most modern sound reproducing equipment available for theatres. It is all a-c. operated, simple in design, compact for easy installation; easy to operate; and requires a low maintenance cost. The over-all characteristic of the system is such as to provide for faithful reproduction of all the audible frequencies from 50 to 10,000 cycles. A curve indicating this response is shown in Fig. 5.

Deaf Headphone System

Provision has been made for the installation of twenty-six outlets located under the arms of alternative seats in the thirty-third and thirty-fourth rows of the orchestra floor into which Acousticon seatphone instruments may be plugged in order that those people who are hard of hearing may more clearly and intelligibly hear the sound motion picture and stage presentations. Each jack-box mounted under the arm of the chair includes two jacks, for permitting the use of two instruments, one with each of the two adjoining seats. The amplifier for this equipment is located on the main amplifier racks of the sound reinforcing systems.

It is intended that individuals can obtain instruments at the box office upon request. Anyone who owns a private instrument designed for this particular use will be permitted to use same if he so desires.

Radio and Monitoring System

The purpose of this equipment is to furnish to the private studios on the studio floor radio pickup of a predetermined number of radio stations and to permit the monitoring of the various sound systems in the theatre and for outside lines terminating within the theatre.

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